Bay of Plenty Dune Lands –
Baseline Report for NERMN programme

Prepared by Nancy Willems, Environmental Scientist

Bay of Plenty Regional Council
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Cover Photo:
View of Moutohora through pingao and spinifex growing on the toe of the dune, east of the Rangitaiki River, near Thornton.

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Executive summary

Dunes in the Bay of Plenty are a significant part of the region's character. At a national level it is estimated that only 11.6% of the original extent of sand dunes remains (Leathwick et al, unpublished report – cited in Ministry for the Environment and Department of Conservation, 2007). In the Bay of Plenty, based on the current mapping, approximately 26% of the historic sand dune landform remains undeveloped. However, undeveloped only means that they are not built-up (housing, roading or other infrastructure), or in agriculture or horticulture. It does not reflect the current state of the remaining undeveloped dunes, some of which are far from their original state with many modifications that are likely to be irreversible.

While natural changes do occur in vegetation, it is becoming increasingly common for our ecosystems to be heavily affected and sometimes driven by exotic species and/or human related impacts. An understanding of what is occurring in the dune vegetation is essential in determining whether or not the ecosystem will remain a feature of the coastal zone in the long term.

Dunes provide specialised habitats for some of New Zealand's native and endemic plant and animal species, some of which are unique to the dunes habitat (e.g. pingao, katipo). All of these species are threatened by habitat loss and habitat change due to impacts like grazing, vehicles, pest plant invasion and predation.

District and regional policies and plans vary in the level of protection they provide for dunes. Legal protection in the form of reserves also provides varying levels of security depending on the reserve designation and the primary purpose of that designation. However, legal protection does not provide any physical protection from damaging influences.

Vegetation cover over the mapped historic dunes landform shows a rapid and significant decline in dune vegetation, with 74% of the original cover lost to developments including urban, agricultural and horticultural activities. Of the remaining vegetation, over half the vegetation types were characterised by exotic species. The transects showed an average of 30% estimated pest plant cover on the transects mapped, with some areas recording over 50% pest plant cover. Higher levels of overall cover were not necessarily associated with housing as might be expected. Very few pest plant species showed a pattern of distribution in the region, with most spread across the full extent from Waihī to Cape Runaway, although with varying density across the transects.

Several threatened and significant plant species occur in the dunes with some reasonably widespread, although not always in large numbers. No fauna surveys were carried out as part of this project and limited information is available. This is a significant gap in the biodiversity information relating to dunes.

Factors impacting on vegetation were also recorded and included foot and vehicular traffic, pest plants and pest animals, dumping of organic and inorganic waste, erosion, clearance and restoration planting. Aside from pest plant control and restoration planting, all these impacts are negative. Litter, pest plants, vehicle and walking tracks were amongst the top five most frequent impacts. Walking tracks were more associated with housing, while vehicle tracks were rare around dense housing and occurred most often in the more 'remote' places away from residential areas. Exotic gardens encroaching into the dunes were generally associated with dense housing. Many activities did not exhibit any pattern of distribution.

Most agencies (territorial authorities (TAs), Department of Conservation (DOC), Bay of Plenty Regional Council (BOPRC)) are involved in some operational work in dunes. Some rely heavily on their contribution to the Coast Care programme to achieve results in dune areas, although this was also supplemented by works carried out by some agencies as separate programmes. Coast Care remains a valuable vehicle for education, attitude change and benefits for biodiversity in the region's dune lands.

The ongoing damage and degradation currently visible on the dune lands through neglect and human activity indicates that dune lands are not adequately protected from damage and degradation. Vehicle use continues unabated, exotic species continue to invade, garden waste continues to be dumped. Rules and regulations under the Reserves Act 1977, the Conservation Act 1987, district and regional plans and policies and council by-laws are not being acted on or enforced consistently across the region.

A more coordinated and thorough management approach that has clear priorities, targets and timelines has the potential to achieve far more than piece meal operations in terms of providing real protection and improvements to the dune condition, although this will always be limited by resources available for each agency. Maintenance and enhancement activities need to take into account the surrounding environment and sources of re-infestation of pest plants, animals and people and a biodiversity or operational strategy could establish linkages to the four well beings (social, cultural, economic and environmental) to achieve this.

There are some aspects of the current monitoring methodology that can be improved. It should still, however, identify changes to the dune systems. We have seen a rapid decline in the extent of dune land vegetation in the past, and further losses should be prevented. It is likely that dune lands will continue to decline in condition if they are not managed for their biodiversity values and indigenous species maintained.

We instinctively know that the dune lands are continuing to be degraded by all of the impacts listed and noted here. As with most ecosystem types in New Zealand, they are generally in at least a slow decline if the impacts upon them are not being managed. We need to increase management activities for biodiversity and ecological benefits and widen the current focus on erosion control to incorporate other goals over a larger proportion of the dune cross-section.

Recommendations

- Add a quantitative component to the methodology (e.g. Scott Height Frequency points on transects). Investigate options for fauna survey and monitoring.
- Re-map the overall extent of the dunes in 2014 as a desktop exercise (with limited field validation, using up-to-date aerial or satellite photography and LIDAR.
- Re-map dune land vegetation in the field in 2019 over the most up-to-date aerial or satellite photography.
- Re-measure transects in 2014.
- Field work should be completed at around the same time each year to reduce seasonal variation, and should be timed to coincide with flowering of grasses to aid identification in summer.
- Improve mapping of areas of actual works undertaken by Coast Care (rather than general activity areas), as this would improve outcome monitoring and enable the vegetation mapping to relate to areas under management and the benefits of that management.
- Expand Coast Care works into the rear dunes to provide wider coverage of the dune ecosystem.
- Continue to utilise Coast Care as a vehicle for education and changing attitudes to dunes.
- Develop some regional guidance on priority pest plants for control in dunes.
- Engage in Biodiversity Management Plans (BMPs) with landowners of dune areas as opportunities arise.

Contents

Tables and Figures

Part 1: Introduction

Bay of Plenty Regional Council's Natural Environment Regional Monitoring (NERM) programme is designed to collect and report on a variety of environmental data, to monitor the suitability and effectiveness of our regional policies and plans and aid in their further development. It contributes to the Council's S35 (Resource Management Act, 1991 (RMA)) "duty to gather information, monitor, and keep records".

The RMA Amendment Act 2003 (S30(1)(ga)) clearly states that regional councils have a responsibility to maintain indigenous biodiversity. This project was established to identify whether or not the dune land ecosystem is being maintained, with a focus on vegetation.

While natural changes do occur in vegetation, it is becoming increasingly common for our ecosystems to be heavily affected and sometimes driven by exotic species and/or human related impacts. An understanding of what is occurring in the dune vegetation is essential in determining whether or not the ecosystem will remain a feature of the coastal zone in the long term. Identifying the extent and frequency of negative impacts is also important, so that options for controlling them can be identified and implemented. This project addresses these needs through the development and application of a methodology to map dune vegetation in the Bay of Plenty.

1.1 Purpose, scope and structure of report

This report presents a baseline for dune vegetation extent and condition in the region under the Terrestrial Indigenous Biodiversity module of the NERM programme.

Chapter 2 discusses the importance of dunes and the threats to them, as well as the issues associated with their recognition as areas of ecological and biodiversity value. Note that these two terms are used interchangeably through the report and in this context generally refer to the more strict definitions of 'ecological' and 'biodiversity'. In relation to ecosystems such as dunes this essentially refers to the indigenous species, communities and systems present.

Chapter 3 provides a brief overview of recent and current monitoring. Monitoring and reporting methods are outlined in Appendix 1 and 2 respectively. Monitoring methods describe the work undertaken to map the extent of the dune vegetation. Reporting methods are about analysis of the information from the mapping work for presentation in the report.

Chapters 4 and 5 summarise provisions for dune land ecosystems in district and regional plans and policies, and the protection they may provide to dunes. The District Councils' reserves management plans are also briefly discussed.

Chapter 6 considers legal protection of the region's dunes in the form of reserves administered by the Department of Conservation and the District Council. There were no other covenant or reserve types that include mapped dune vegetation.

Chapter 7 examines vegetation change over the historic dunes landform from 1840 to 2001/2002 and to the current dune land vegetation extent mapping completed in 2009. This includes threatened and significant indigenous plants found. This chapter also discusses elements of the condition of dune vegetation including pest plant and impacts that are generally, but not always, related to human activities in and around the dunes.

Chapter 8 describes work programmes by the different agencies (Bay of Plenty Regional Council, Department of Conservation, territorial authorities), and the community, that provide for management of the dunes and the biodiversity values there.

Chapter 9 draws together information presented in the earlier sections of the report. It is subdivided by each subject heading and tries to draw all the elements together to determine whether or not our dune lands have adequate protection.

Chapter 10 lists recommendations that have resulted from the chapters listed above.

This report is focussed on biodiversity and ecological values. All discussions aim to look at how a particular factor can be beneficial or detrimental to those ecological values. Coastal hazards are outside the scope of this report and are only mentioned briefly. There is no attempt made to relate vegetation mapping to erosion or accretion monitoring sites along the sandy coast as this is only considered relevant where the dunes may be squeezed out between sea level rise and protection of infrastructure and property.

Part 2: Dune lands in the Bay of Plenty region

Dunes in the Bay of Plenty are a significant part of the region's character, with extensive beaches and dunes sweeping along the Bay of Plenty's coastline. Dunes are one of the most dynamic ecosystems in our environment (Hesp, 2000), with short and long term trends in shape, accretion and erosion processes (Iremonger, 2007). They are identified in the New Zealand Coastal Policy Statement as a national priority ecosystem and are recognised as being an integral part of the natural character of our coasts (Department of Conservation, 1994).

Dunes form where there is shelter from strong waves, a supply of sand, onshore winds strong enough to move sand particles, and dune binding plants (Partridge, 1992; Hesp, 2000). Dry sand is blown inland from the beaches by onshore winds, where it is stopped by existing fore dunes, and the sand binding plants on those fore dunes capture and hold the sand (Partridge, 1992). Onshore winds will also transport dry sand further back off the incipient fore dunes[1] and form more extensive dune series and complexes, depending on the available supply of sand. These established fore dunes tend to be more stable. The plant species that occur there are specifically adapted for the conditions. They restrict wind action and begin to build up organic materials which can be colonised by other plants once the dunes are firmly stabilised (Partridge, 1992). Fore dune height and stability is quite variable, from stable and densely vegetated to sparsely vegetated and highly unstable (Hesp, 2000).

At a national level, it is estimated that only 11.6% of the original extent of sand dunes remains (Leathwick et al, unpublished report – cited in Ministry for the Environment and Department of Conservation, 2007). In the Bay of Plenty, based on the current mapping, approximately 26% of the historic sand dune landform remains undeveloped. This is an improvement on the national statistic. However, although these areas are undeveloped, this only means that they are not built-up (housing, roading or other infrastructure), or in agriculture or horticulture. It does not reflect the current state of the remaining undeveloped dunes, some of which are far from their original state with many modifications that are likely to be irreversible.

2.1 Importance of dunes

igure 1 Spinifex-pingao grassland.

The importance of dunes in terms of ecosystem, habitat and biodiversity is often forgotten or ignored. For flora and fauna the conditions are harsh. Temperatures vary widely and moisture is quickly evaporated by wind, salt spray, and heat (Auckland Museum website, 2010). Species present in the dunes, both flora and fauna, have adapted to cope with these conditions.

[1] See Appendix 8 for definitions of dune landforms.

2.1.1 **Flora**

The dunes provide specialised habitats for some of New Zealand's native and endemic plant species. Dune plants are an integral part of the dune building, erosion and repair processes and some species, such as pingao (*Ficinia spiralis*), spinifex (*Spinifex sericeus*) and sand convolvulus (*Calystegia soldanella*), are unique to the dunes habitat. These sand binding plants are particularly adapted to a dynamic system that buries them and forces them to grow up through the accumulating sand. Their foliage traps moving sand, thereby building up the dune formation. Loss and damage to dune vegetation impedes the ability of the dunes and dune plants to maintain an equilibrium dune profile. A typical dune vegetation sequence is shown in Figure 2, although New Zealand now has very few examples of dune sequences that continue into forest.

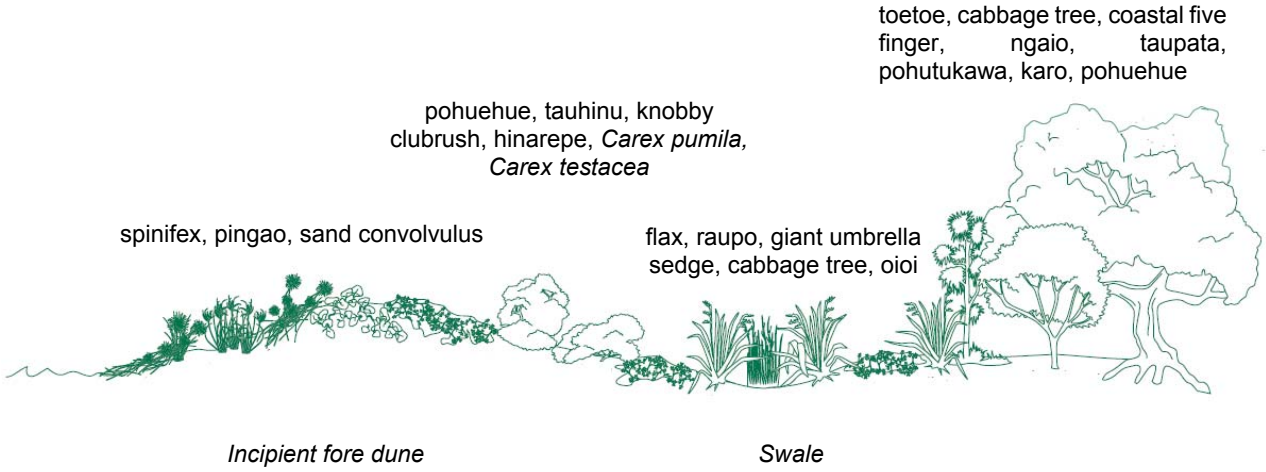


Figure 2 *Typical dune vegetation sentence (Adapted from Auckland Regional Council Coastal Planting Guide Number 2 – Dunes).*

Some dune species are considered to be nationally at risk of extinction, including pingao (At risk, relict[2]), sand coprosma (*Coprosma acerosa* - At risk, declining) and hinarepe (*Austrofestuca littoralis* – At risk, declining). The Bay of Plenty has its own unique species of kanuka found in New Zealand only on the dunes between the Tarawera and Whakatāne Rivers. It is a local endemic that is acutely threatened at a national level (de Lange *et al*, 2009). Ongoing damage to threatened species and loss of suitable habitat may result in extinction of these species in the long term.

Figure 3 *Thornton kanuka shrubland – this species is endemic to the Bay of Plenty.*

[2] National threat rankings from de Lange *et al*, 2009

2.1.2 **Fauna**

Katipo (red - *Latrodectus katipo,* black - *L. atritus*) have been recorded in the Bay of Plenty's sand dunes, although they have only been found at a few locations in more recent studies (Matakana Island, Pāpāmoa, Kaituna, Maketu and Pukehina (Sutton and B Christensen, in prep; de Monchy, 2010 pers comm)). Katipo are dune land specialists (Patrick, 2002). They are considered threatened and in serious decline (Hitchmough *et al*, 2007), with numbers falling, geographical range shrinking, and populations becoming increasingly fragmented (Patrick, 2002). The main reasons for their decline appear to be loss of habitat and a decline in the quality of the remaining habitat (Patrick, 2002).

Other invertebrates have also adapted to the dunes ecosystem. The tiger beetle (*Neocicindela tuberculata*) is a predator of other small insects. Sand scarab (*Pericoptus truncates*) are a nocturnal beetle with larvae that feed on driftwood. The black spider hunter wasp (*Pricocnemis nitidiventris*) stings and paralyses small wolf spiders, and lay their eggs in the body that is eaten by the larva when it hatches (Auckland Museum, 2010). The copper butterfly (*Lycaena salustius*) lives for only 10 days, and the caterpillar feeds on pohuehue. The invertebrate fauna of dunes in the Wellington dunes was found to be reasonably diverse with 22 orders found across six study sites (Jamieson, 2010). The perceived difficulty of surveying invertebrates and processing samples means that information is sparse.

Reptiles such as shore skink (*Oligosoma smithii*) are likely to have been present prior to major changes in the dunes, however little is known about their current populations. There is some anecdotal evidence that they are still present at some sites along the coast.

Several bird species such as variable oystercatcher (*Haematopus unicolor*) and northern New Zealand dotterel (*Charadrius obscurus aquilonius*), depend on sandy beaches and dunes for feeding and nesting sites.

Identifying fauna present in the dunes was outside the scope of this project, which focuses on vegetation mapping; however it should be considered a major gap in our knowledge of dune land biodiversity and steps taken to fill that gap. Restoration activities can assume that provided the appropriate vegetation exists, the fauna will return, but monitoring may not be in place to determine whether that actually happens or not. Highly mobile species are likely to be able to re-colonise, but the assumption is unlikely to be true for ground dwelling reptiles and invertebrates. If we have no information about what currently exists on the dunes we are unable to determine whether or not our management has been successful for all elements of biodiversity, rather than just re-establishing indigenous vegetation cover.

In addition to biodiversity values, coastal dunes act as a store of sediment which protects the hinterland from storm erosion, inundation and possible future sea level rise (Hesp, 2000). An intact dune system can provide some protection for infrastructure and property in the coastal environment from storm surges and wave action. Dunes filter rainwater and groundwater (Hesp, 2000). Loss of dune systems results in the loss of amenity values of those open areas.

2.2 Threats to dune lands

Unfortunately dunes have often been considered in a negative light, and as an impediment to the development of more productive lands. Even one of our earliest and most prominent botanists, Leonard Cockayne, describes dunes in negative terms. He thought that "…their movement inland [was] a national concern, since through their advance much valuable land has been ruined in the past, while yearly further destruction takes place, the evil at the same time becoming more difficult to suppress" (Cockayne, 1909).

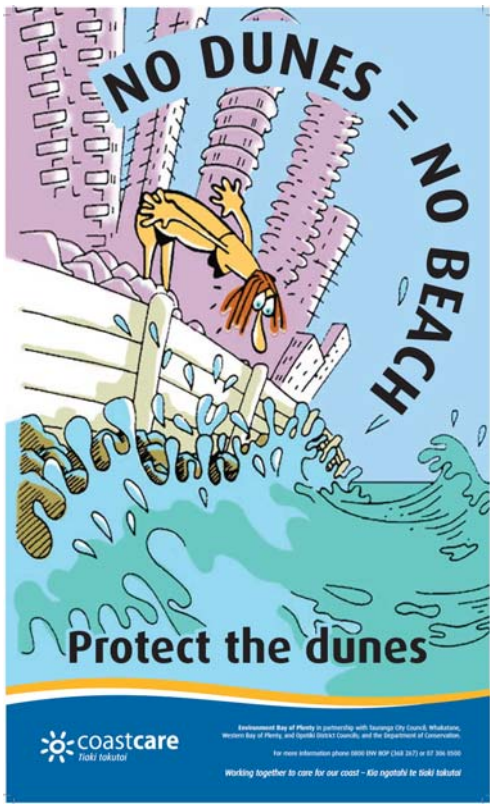
Despite recognising that fore dunes included unique plant species, and dunes that were covered and fixed by plants provide some natural protection from incursion by the sea, his interest in fixed dunes related more to the reduction of sand supply so that dunes would not grow and travel as they did in some parts of the country (Cockayne, 1909), allowing the dunes to stabilise and be developed. Dunes were variably referred to in negative terms as "sand-infested areas", "evil" and "insidious" and Cockayne (1909) concluded that "the final treatment of dunes should assuredly be afforestation…"

Even in 1909, when Cockayne had been hired to report on the potential and methods to develop the dunes into productive land, grazing, clearance and fire had already changed the dunes and reduced their extent. Ever since human settlement, dunes have been heavily impacted by human activity and remain under constant pressure from coastal development and access.

Dune ecosystems are extremely vulnerable to modification in the form of large or small-scale subdivision and housing development, vehicles and other recreational human activities, damage to dune vegetation from tracking and pest animals, and invasion by exotic plant species. This list is not exhaustive and multiple impacts acting on the dunes simultaneously serve to exacerbate the impacts and speed of decline of biodiversity. All of these factors can also affect the erosion and accretion processes in the dunes, and pressure to maintain human assets can result in engineering options that compromise natural processes even further.

2.2.1 Housing and other development

Coastal areas continue to be targeted as desirable areas for housing. While the RMA provides for protection from "inappropriate subdivision, use and development", definitions of 'inappropriate' are open to interpretation and views vary greatly. This makes coastal areas even more vulnerable as it relies on the understanding of consenting authorities of what they consider to be appropriate development. This understanding can be easily moved in favour of developers where there is community pressure, demand for further suburban development and market pressure for coastal property.



Development also threatens to 'squeeze out' dune lands with sea level rise. Prior to any development of the coast, residential or production, a rise in sea level would have resulted in new dunes being developed further inland. It is unlikely that human nature will

allow the loss of productive systems or structural property to allow this to happen, so as the sea level rises dunes will become an increasingly narrow strip between the ocean and property. It is more likely that extensive engineering will be brought into play in an attempt to protect human assets. So despite the fact that dunes go through natural erosion and accretion cycles over different time scales, we are constantly trying to prevent all erosion cycles to protect property, which alters the long term dynamics of the dune system (Hesp, 2000). We are already trying to reduce the effects of erosion events along the coast because of the position of some houses at sites like Pukehina and Waihi Beach, and this situation will only escalate with sea level rise.

Dune land ecosystems in the Bay of Plenty are confined to the coastal environment. They are part of a dynamic environment that cannot be replicated away from the coast and the processes that form them. This means that off-set mitigation for the loss of part of the dune system is not possible[3], and avoidance of the destruction of dunes through development and use is the only option if they are to be maintained as a feature indefinitely. The five-year review of the New Zealand Biodiversity Strategy (2000) (Green and Clarkson, 2005), identifies the "dominance of economic drivers that favour the degradation of ecosystems … rather than their active maintenance" as a significant challenge that still needs to be addressed. Given the rapid population growth in parts of our region, particularly in the Western Bay of Plenty, this statement has a great deal of relevance to the Bay of Plenty.

Less obvious threats to our dune lands come in the form of exotic invasives, both plants and animals. Dune land fauna is generally not an obvious component, partly because fauna populations have been vastly reduced due to habitat loss and predation. Because this work focuses mostly on vegetation, fauna will not be discussed in any depth. However our experiences in other ecosystems, and the small amount of knowledge we do have about fauna in dune lands, suggests that they are affected by the same impacts as fauna in other places.

2.2.2 Invasion by exotic plants and animals, and other human activities

While our dune lands appear to be wild, and there is likely an assumption on most people's part that they are still a natural ecosystem, such appearances are deceiving. Dune vegetation in New Zealand bears little resemblance to a totally natural and unchanged system, and is in fact being progressively invaded and altered by exotic plants. Around half of our Bay of Plenty dunes are estimated to be dominated by exotic species, based on their vegetation types as mapped in this project. While some exotic species are of more concern than others, the fact remains that over time exotic species may come to dominate our dune systems, leaving little of the native character that is largely unique to New Zealand.

A major threat is posed by the invasion of dunes by exotic grasses like sea couch, kikuyu, Indian doab, buffalo grass and veld grass. All these grass species tend to escape notice while slowly coming to dominate the dunes and prevent regeneration of indigenous species.

Garden escapes, dumping of green waste, and encroachments into the dunes are a significant problem around areas of high density housing such as Pāpāmoa and Ōhope, and on the very narrow band of fore dune in front of the houses at Pukehina. Exotic plants, especially those that have no sand binding ability, either do nothing to stabilise dunes or alter the form of the dune. For example, marram may stabilise dunes but it results in a steeper formation than native species like pingao

[3] Note that offset mitigation should result in no net loss, and the mitigation should replace like with like. It is not sufficient to replace a lost area of dune with a forest or wetland elsewhere, nor does the enhancement of another area of dunes replace the permanent loss of an area being developed. (M Christensen, 2010)

and spinifex (Esler, 1970; Hesp, 2000). Other species like South African iceplant and gazania provide little protection from storm surges.

Parts of the historic dune land landform have been developed into pasture, and some areas of remaining dune vegetation are being grazed to the point of destruction. Areas of open sand and erosion in stable dunes are common adjacent to farmed areas and the Thornton area provides a number of examples. East of Ōpōtiki dune areas are also often grazed by horses and other stock. Domestic stock severely damage dune vegetation by grazing, trampling and transporting pest plants from other areas. Manure inputs also change the nutrient status of dunes and make it more accommodating to higher nutrient demanding exotic species that are not adapted to the sandy soils of stable dunes and fore dunes. As the process of invasion continues, organic matter and nutrient inputs continue to speed the incursion of non-native plant communities.

Vehicles have been recognised as a major threat to dunes because of their outright destruction of dune vegetation. Vehicle tracks are extensive throughout the remaining dune areas in the region. Bylaws and regulations have had limited effectiveness in reducing vehicle impacts on extensive parts of the dunes, particularly in those areas that are not backed by areas of housing, such as the dunes from Ōtamarākau to Whakatāne.

Other recreational activities like horse riding, motorbike riding and even walking, similarly damage and destroy dune vegetation.

Most of the fauna on our sandy coastlines are threatened by habitat loss and habitat change (e.g. shifts in species composition and structure) due to activities like grazing, vehicles on dunes, invasion by exotic plant species and shifts in composition to vegetation types that are no longer suitable for dune specialists. Predation by cats, rats, mice, mustelids (ferrets, stoats and weasels) and dogs is also an ongoing issue.

Perhaps one of the greatest threats to dunes is that aside from members of Coast Care, the general public do not appear to value the dunes for their biodiversity. Dunes, to varying degrees, are treated as adventure playgrounds, roads and garden rubbish dumps. They are not viewed with the same level of respect as more charismatic examples of indigenous biodiversity like kokako, or kauri trees. Until this attitude changes any headway made in protection and restoration will be limited, unless an economic incentive can be attached to the maintenance of dunes.

2.3 Recognition of dunes as Significant Natural Areas

Identifying and documenting natural areas of ecological value has been reasonably extensive throughout New Zealand, through the Protected Natural Areas Programme (PNAP[4]), and through District Planning processes requiring the identification of significant natural areas (SNAs[5]) under the Resource Management Act 1991. The identification of dune lands by the criteria followed under PNAP and SNA processes can be problematic. Dunes often do not score well under criteria relating to diversity, viability and naturalness. Dune lands are generally modified to some degree and are often long narrow strips along the coast with no buffering, which compromises long term viability. Unique dune land fauna and scattered populations of threatened plants are not highly visible and rapid assessment methods can easily miss them.

[4] PNAP was established to systematically survey New Zealand to identify the most significant sites for protection. New Zealand is surveyed on the basis of Ecological Regions and Ecological Districts and is the responsibility of the Department of Conservation.
[5] Responsibility of the territorial authorities in order to meet the requirements of Section 6 (c) of the RMA.

Fauna are recorded only when and where they are seen during the course of the work, and are not actively sought, although fauna information is supplemented by background research.

The lack of recognition for dune lands under the PNAP and SNA processes is a concern because these are the programmes that most people look to for an indication of what is of ecological value, and the identification of significant sites is the first step to providing them with physical and/or legal protection. The Partridge (1992) inventories of beach and sand dune vegetation attempted to more clearly identify dune lands as sites of significance for biodiversity. Hilton *et al* (2000) sought to update the Partridge (1992) inventory to look at the remaining active dune lands and look at trends in the rate of loss at regional scales, thereby adding to the understanding of the conservation status of the remaining dunes.

More recently the National Priorities for Protecting Rare and Threatened Native Biodiversity on Private Land (Ministry for the Environment and Department of Conservation, 2007 - see Appendix 3) has highlighted the need to specifically focus on habitats that are not well represented in the national network protected natural areas. The National Priorities also specifically targets the areas of biodiversity that are most vulnerable nationally. In New Zealand, despite covering 30% of our land area, public conservation lands mostly protect biodiversity on higher country (Ministry for the Environment, 1997) and include a high proportion of mature forest areas. Public conservation lands do not protect the full range of ecosystems and habitats present in New Zealand. Natural areas in the lowlands and vegetation types other than forest are not well represented and other recognition is needed.

Sand dunes are specifically listed in National Priority 2 (Ministry for the Environment and Department of Conservation, 2007) because they have been significantly reduced in extent by human activities. In addition they generally fall on Land Environments with less than 20% remaining indigenous cover (National Priority 1), and the occurrence of threatened species in many parts of the dunes also triggers National Priority 4. The fact that dunes are a national priority under three sets of criteria emphasises the need to maintain and enhance whatever remains.

The National Priorities have yet to be widely incorporated into regional and district planning processes.

Part 3: Overview of previous and current monitoring

The Terrestrial Indigenous Biodiversity (TIB) module of NERMN was initiated in 2001, with wetlands and coastal forest as the initial priorities. Dune ecosystems were identified as the next priority. Two trials were undertaken to develop suitable methods for monitoring the condition of dunes (Taylor, 2005) and mapping the extent of dune vegetation (McNutt *et al*, 2006). It is more intuitive to first map the extent and then develop a sampling strategy for condition monitoring, however the aerial photography available at the time was not of sufficient resolution to undertake a mapping exercise[6]. The vegetation condition trial did not use a statistically robust sampling strategy and employed a number of different quantitative and semi-quantitative data collection methods in an attempt to find the best methods. The data was stored in various spreadsheets, however there were no re-measures and the data was never analysed. The subsequent vegetation mapping trial (McNutt *et al*, 2006) used aerial photography from 2003. It mapped broad vegetation types at selected sites, recorded a condition score for each vegetation polygon, and the identified presence/absence of human impacts. This work provided part of the basis for the vegetation mapping undertaken in this exercise.

There were a number of what I considered to be key elements in the development of the current methodology. The 2007 aerial photography attains a higher resolution than the 2003 photography and is therefore much more useful for this type and scale of mapping. The needs of the Regional Council were considered to be less about the finer points of dune land vegetation ecology such as detailed vegetation structure and composition, and more about the overall maintenance of dune land vegetation that retains its indigenous character, and where indigenous species are the main drivers of the ecosystem. A system that obtained complete coverage of the remaining dune land vegetation was essential, and elements being measured had to relate back to the Regional Council's requirements to maintain indigenous biodiversity, and the factors present on the dune lands that are impacting on that biodiversity.

The mapping covered the mainland and Matakana Island but does not map dune areas on any other islands.

[6] The 2003 Regional Digital Aerial Mosaic (RDAM) was not available at the time this work was undertaken (Taylor, 2005). The RDAM is a set of ortho-rectified aerial photography covering the region.

Part 4: Regional policy and plan provisions for dune land ecosystems

One of the functions for regional councils under S30 (ga) of the RMA 1991, is "the establishment, implementation, and review of objectives, policies, and methods for maintaining indigenous biological diversity". This means that regional councils are required to develop plans and policies for indigenous biodiversity, mostly focussing on significant indigenous biodiversity as per the Matters of National Importance, S6(c) of the RMA. Provisions in regional and district plans and policies are one tool that aims to achieve this requirement.

4.1 Regional Policy Statement

The Regional Policy Statement (RPS; operative 1 December 1999) has its purpose set out in section 59 of the RMA as follows:

"The purpose of a regional policy statement is to achieve the purpose of the Act by providing an overview of the resource management issues of the region and policies, and methods to achieve integrated management of the natural and physical resources of the whole region."

The Operative RPS is really an overarching guiding document and is currently undergoing a formal review. A RPS does not in itself provide the protection, but it does direct regional and district plans to do so, and strong guidance is needed to achieve that in a consistent way.

The Operative RPS recognises natural heritage as being of importance and groups the objectives, policies and methods in two sections: Preservation and Protection; Ecological Restoration and Rehabilitation. Dune lands are not specifically mentioned as an ecosystem type, which may undermine the recognition of the values of dunes against other habitat types, however the policies are generally appropriate for any ecosystem type and cover the bulk of the issues in dunes. The distinction between protection and restoration is important in recognising that degraded ecosystems still have values which can be restored, as in the dunes.

The weakness of the RPS is that the methods of implementation are not strongly worded, mostly using the term "are encouraged to", rather than "will" or "shall". This means that not all the District Councils have necessarily taken up any one piece of guidance and applied them at District Level, and as a result dunes have only attained variable protection.

The Draft RPS (2009) is more forceful and provides stronger direction to the requirements of District Councils. It uses the words "will" and "shall" more frequently, and also provides timelines where the policy and/or method may require a review of the District Plan. Matters of National Importance are identified in their own section, although somewhat diluted by the mix of cultural and natural heritage matters. The issues succinctly cover the main concerns for biodiversity values, although dunes will need to be specifically added to the text to highlight them as an ecosystem type that needs attention. It is hoped that the more prescriptive approach will provide more consistent levels of protection across the region for dunes, however the public submissions process is not yet complete and some provisions may change.

4.2 Bay of Plenty Regional Coastal Environment Plan

The Bay of Plenty Regional Coastal Environment Plan (operative 1 July 2003; hereafter referred to as the Coastal Plan) includes policies relating to the maintenance, enhancement and restoration of the coastal environment and its ecological integrity. The plan identifies four zones: the Coastal Habitat Preservation Zone (CHPZ), the Port Zone and the Harbour Development Zone, which are spot zones with specific provisions relating to specific areas within the coastal environment. The fourth is the generic Coastal Management Zone (CMZ) which includes all other sites in the remainder of the coastal environment.

The CHPZ acts as an overlay of ecological significance and all habitats identified as being of international, national or regional significance are automatically included in this zone. The emphasis in the CHPZ is on the exclusion of "all activities which may have any actual or potential adverse effects on the habitats in this zone". Most activities are identified as Prohibited. The CHPZ includes habitats identified by the Department of Conservation as supporting significant numbers of "at risk" threatened species. Sites identified in the CHPZ generally fall below mean high water springs and less than 1 ha overlaps with mapped dune vegetation.

Habitats that are of district or local significance, including those that support reasonable (but not significant) numbers of threatened species, are not included in the CHPZ. These sites fall within the generic Coastal Management Zone but are identified on planning maps as Sites of Significance on Land (SSL) or Sites of Significance in the coastal marine area (SSCMA). Activities within the CMZ are considered on a case by case through the consenting process, taking into account the values of the site and the effects of the proposed activities. Most activities in this zone are discretionary. Sites of District and Local significance includes a very small proportion of the mapped dune land vegetation, only 11.54 ha or 0.6%.

Sites identified as CHPZ, SSL or SSCMA are identified in the sixth and seventh Schedules of the Coastal Plan.

While the Coastal Plan includes identified and scheduled Sites of Significance on Land (SSL), the rules do not extend outside the coastal marine area and therefore the Coastal Plan provides them with no protection. The expectation was that the District Councils would "take appropriate steps" with resource consents that may have an adverse effect on these sites, and eventually have rules in their district plans that afford lasting protection. The SSL schedule covers 45.5% of the mapped dune vegetation.

In summary, the current Coastal Plan does not provide protection for the vast majority of the dune land vegetation. It does restrict vehicle use, but this is not enforced.

More recently, work was commissioned to identify significant indigenous vegetation and habitats (Wildland Consultants, 2006) in preparation for a review of Volume 2 of the Coastal Plan (planning maps). This identified 81% of the dune land vegetation areas as significant. The sites identified are also given a relative significance ranking of National, Regional or Local, based on their overall ecological values and condition. The table below summarises how much of the mapped dune land vegetation each of these covers.

Table 1 Summary of dune land vegetation covered by Wildland Consultants (2006).

Site ranking	Hectares	% of total dune land vegetation
National	1,070.74	48.2
Regional	474.18	22.4
Local	213.49	10.1
ALL	**1,708.41**	**80.7**

The advantage of the greater coverage of dune land vegetation in the most recent report (Wildland Consultants, 2006) is that it will highlight the importance of providing protection for them, but still relies on the District Councils taking up their responsibility to make provisions in their District Plans. In addition there may be delays where District Plan reviews are required to act on this.

If the review of the Coastal Plan follows a similar approach to the current plan, protection can only be guaranteed for nationally significant sites that fall below mean high water springs. The review proposes to delineate all sites of ecological significance into separate ecosystem types as a way of ensuring that the best representative examples of each (including dune vegetation) are included in the CHPZ. Nationally significant sites are proposed to be included in the CHPZ. Sites identified as regionally significant in Wildland Consultants (2006) will be filtered to draw the best representative sites into the CHPZ. The remaining regionally significant sites, and locally significant sites will fall under discretionary rules, which require resource consent for activities to occur within those sites. This approach would provide good protection for nationally significant sites and the best of the regional sites. It may leave the remaining sites slightly more vulnerable as a discretionary consent may still be granted for an activity, however any applicant would have to prove they can avoid/remedy/mitigate the effects of their activity.

4.3 Regional Water and Land Plan

The Regional Water and Land Plan (RWLP; operative 1 December 2008) acknowledges that the protective function of coastal sand dune systems can be reduced as a result of land use and management practices that are inappropriate to a site. It notes that this increases the risk of erosion and flooding from storm events along the Bay of Plenty coast, and addresses the maintenance of sand dunes in some rules.

The RWLP rules do allow some activities in the dune lands. It provides for a small amount of earthworks as a permitted activity in dunes at least 50 metres inland from the Coastal Marine Area. Works from 0-20 metres inland from the Coastal Marine Area are a discretionary activity which means that consents can still be given for these activities. Coast Care works to re-contour dunes within set limits is a permitted activity, presumably because these works should be beneficial. Larger scale Coast Care works are controlled to allow consideration of the effects and to ensure any adverse effects are controlled, remedied or mitigated. Unless there are preventative provisions in a district plan, vegetation clearance can also occur, provided the land and soil is not disturbed. It would require consent to cultivate land in the coastal marine area, however the likelihood of an application is low given that many crops will fail on such sandy soils. Grazing of stock is a permitted activity provided it does not cause or induce erosion to land. Other activities then become discretionary. It is interesting to note that grazing of stock around Thornton is inducing erosion on historic sand dunes but only some of this is being addressed through land management programmes with Bay of Plenty Regional Council, and it is unlikely that any of those landowners have been required to obtain consent for the activity.

When assessing resource consent applications for discretionary activities the RWLP does include objectives and policies that include the need to maintain the protective function of the dunes, but does not exclude the possibility of various activities gaining consent.

4.4 Regional Pest Management Strategy

The purpose of the Regional Pest Management Strategy (RPMS; Operative 27 November 2003) is "to provide for the efficient and effective assessment, management and/or eradication of pest plants and pest animals in the Bay of Plenty Region…." It identifies a list of pest plants and pest animals and groups those under five categories: Eradication; total control; progressive control; boundary control; regional surveillance (details of the categories can be found in the RPMS document). No one may knowingly spread, sell, display or propagate any of the pest plants featured. Each category determines the respective responsibilities of landowners and the regional council for their control.

Under the current operative RPMS many pest plants found on the dunes were not included (see Appendix 4). Those that are listed in the RPMS are included in the progressive control, boundary control or regional surveillance categories. Progressive control plants are required to be controlled by land occupiers unless an approved programme is being undertaken by the Bay of Plenty Regional Council, however this category only included five species (boneseed, bushy asparagus, lantana, woolly nightshade and wild ginger). In addition, the requirement for the landowner to control these species is unlikely to be enforced on the dunes. Boundary control plants are only required to be removed within a particular distance from the property boundary. Regional surveillance plants are not required to be controlled at all.

In the proposed RPMS there is much greater inclusion of pest plants found on the dunes, doubling the list from 16 to 32 species. Most of the species not included in the operative RPMS have moved into the restricted pest category. This means that although they are acknowledged as pests, landowners/occupiers will be responsible for their control and the regional council will have no authority to force the control of these species. This has potentially significant implications in terms of ongoing weed invasion of natural areas like dunes, particularly from wind and bird dispersed species which can spread quickly. Coastal tea tree was the exception to this and was moved into the containment pest category, meaning that it is still practicable to control it and there is an ongoing programme for this on Matakana Island. None of the pest plants found on the dunes is in the eradication category.

Under both the operative and the proposed RPMS there is very little push for the control of pest plants with potentially devastating effects on the dunes. It would not be pragmatic to force the control of all species across the dunes, as some landowners such as the district councils do not have the resources to achieve good control. Unfortunately however it also means that there is nothing to induce landowners of dunes to control pest plants there and neither the operative nor the proposed RPMS provides a mechanism to bring about restoration of the dunes.

Part 5: District Plan provisions for dune land ecosystems

Territorial authorities (TAs) are required under S31 of the RMA to control the "actual or potential effects of use, development or protection of land" including for the purpose of the maintenance of indigenous biodiversity. District Plans in the Bay of Plenty region aim to achieve this in different ways. However all the District Councils have, at some stage, identified and mapped natural areas that meet a definition of significance, with regard to Section 6(c) of the RMA.

Most districts with an open coast boundary achieve good coverage (see Table 2) in their identification of significant natural areas on the dunes, with the notable exception of the Western Bay of Plenty (WBOP) District. They identify 7 ha of the dunes as significant natural areas in their Operative District Plan[7]. This constitutes 0.9% of the total dune land vegetation mapped for the WBOP District. Excluding Matakana Island, which is a unique situation[8], from the calculations only brings the percentage up to 3.7%. Their identification of sites scheduled in the district plan was first undertaken as a desktop exercise, with some of this earlier work updated with the release of a new report (Beadel, 2006). Scheduled sites include areas on the dunes that were later field assessed and ranked variably from not significant, right through to nationally significant (Wildland Consultants, 2006). The schedule fails to identify the nationally significant dune system of Matakana Island's seaward shore, and other ecologically significant dune areas in their district.

While the scheduled sites can be the result of the political climate and planning considerations, it is disturbing to note that in a district where the coast is under such heavy pressure from existing and future development, very little of the dune lands have any recognition in the district plan. It must be noted that some of the areas not identified do have some reserve status providing a level of legal protection, but as discussed later in the report, this doesn't necessarily provide protection for the ecological values of the dunes. In addition, the variable inclusion of sites in the WBOP schedule indicates a lack of consistency in assessments and/or exclusion of sites on the basis of public submissions rather than ecological values. The RPS Heritage Criteria attempt to address inconsistency in assessments across the District Councils. The more direct application of the National Priorities could also go some way to addressing this gap.

While not all the districts provide additional protection to sites either scheduled or otherwise acknowledged in their District Plans, recognition of those sites in the District Plans is still important as it identifies areas of value for the general public, and highlights them for consideration during consenting processes. The rest of the TAs achieve good coverage of their dune lands through the SNA processes, with Whakatāne identifying 90% of their dunes as significant in Beadel et al (1996).

[7] Note that the sites included in the schedule are those that made it through the District Planning process. There were many sites originally identified that were excluded through the public submissions process, despite being identified in the original survey. The Natural Heritage Chapter is currently going through the public submissions process, and this figure may change.

[8] The Western Bay of Plenty District Plan provides for the development of a "Whole of Island" plan. It often excludes Matakana Island from general rules relating to development and subdivision, and has additional policies that apply only to Matakana Island. It is considered that the island is a sensitive environment and that development has potential to adversely impact on archaeological, cultural, spiritual, ecological and landscape values. The WBOP District Plan attempts to address the need to ensure that large-scale or more intensive development proposals do not compromise future options for the comprehensive planning and development of the Island. The bulk of the island is in private ownership to mean high water springs.

Table 2 Areas of mapped dune land vegetation identified as significant by the territorial authorities.

District	Area (ha) dune vegetation mapped in the District	Area (ha) of mapped dune vegetation identified as SNA	Proportion (%) of mapped dune vegetation identified as SNA
Western Bay of Plenty	764	7	0.9
Tauranga City	279	217	78
Whakatāne	682	613	90
Ōpōtiki	393	301	77
TOTAL	***2118***	***1138***	***54***

Collectively just over half the dune land vegetation mapped in the Bay of Plenty Region has also been identified as significant natural areas by the territorial authorities.

5.1 Ōpōtiki District (Operative May 2010)

There is some protection for dune lands within the Ōpōtiki District Plan. Policies include the requirement for set-backs to keep development off coastal ecosystems, a programme for the identification of indigenous vegetation and habitats of importance in the coastal zone, and avoiding adverse effects on features scheduled in the Operative Regional Coastal Environment Plan. Disturbance of coastal dune land vegetation greater than 100 m² is a discretionary activity. Ōpōtiki lists seven wetlands and some landscape features in its schedule, but this does not appear to provide greater protection of dune lands.

5.2 Whakatāne District (Proposed February 2010)

There are a variety of policies in the Whakatāne District Plan relating to protection of natural character, ecological and habitat (including aquatic) values associated with the coast, from inappropriate subdivision, land use and development. These aim to retain natural features and processes for natural hazard mitigation, thereby providing some protection for dune lands in their capacity to protect houses from storm surge and erosion. In the Coastal Hazard zones policies extend to retaining and actively providing for preservation and, where possible, enhancement of dunes and positioning of housing to avoid potential erosion issues in the future.

Under discretionary activities Whakatāne District Council has retained discretion over a fairly comprehensive suite of factors that should protect dunes to some degree, although some activities that damage or destroy dunes may still gain consent. Whakatāne District does not have a natural heritage chapter in their operative plan, and does not list a schedule of sites, so there are no rules to protect biodiversity values.

Most of the dunes in the Whakatāne District are administered by the Whakatāne District Council, or the Department of Conservation. A new Natural Heritage Chapter is being developed currently.

5.3 Western Bay of Plenty District (Proposed February 2010)

The Natural Environment Chapter provides rules but these only apply to identified sites scheduled in the District Plan. As already noted, this covers a very small proportion of the dune lands that occur in the Western Bay of Plenty District. Some dunes are administered by the District Council or the Department of Conservation, and this is likely to provide a greater degree of protection over those areas than the rules in Chapter 9.

The Natural Hazard chapter includes policies to conserve and enhance natural features such as sand dunes because of their capacity to protect private land, and to allow for them to migrate inland in the future. Where dunes are within the Coastal Protection Zone they are afforded some protection from activities within that zone.

5.4 Tauranga City Council (Operative May 2010)

The Tauranga District Plan identifies the coastal areas as significant landscapes which should be protected. Sustaining natural resources by protecting the functioning and integrity of ecosystems is one of their objectives. Policies within that objective cover a range of ecological values that should be protected from use and development within the coastal environment. As well as covering areas scheduled as Special Ecological Sites, there are also provisions for sites identified by other organisations by other methods such as the PNAP.

Vegetation clearance areas are controlled by rules, however these rules relate to native forest and areas within or adjacent to Special Ecological Sites, not to indigenous vegetation in general, leaving a little over 20% of the dune vegetation in the Tauranga District with no protection under their District Plan.

The Natural Resources chapter is being reviewed.

5.5 District Council bylaws

Provisions that may provide some protection for dune lands are also made by the TAs through their bylaws. All the TAs in the Bay of Plenty have very similar bylaws, and beach bylaws that include dunes as part of the adjacent coastal environment. Reserves bylaws also cover dune lands where they are part of reserves.

All district councils have bylaws that prohibit littering. Wandering and grazing of stock in reserves is not permitted by any council. Vehicles and horse-riding access to the beach is restricted to authorised or designated access points, and for specific purposes. Western Bay of Plenty District Council specifically notes that horses may not be led or ridden in the dunes, and Tauranga City Council specifically mentions quad bikes may not be ridden in the dunes. Vehicles and animals may also not be ridden, parked or driven on a reserve outside areas set aside for those purposes, without permission. Fires are not allowed in public places, which include reserves. All Councils also included in their bylaws that damage to vegetation or natural features was not permitted and fires may not be lit outside designated areas. Wildlife is not allowed to be interfered with in any way, although species protected under the Wildlife Act 1953 are to be dealt with under that Act.

Part 6: Legal protection for dune land ecosystems

Legal protection for the region's dune lands in the form of reserves is achieved through the Department of Conservation and the District Councils. Between them they administer a total of 39.3% of the region's dunes as reserve lands. Most of this falls to the District Councils, with some large areas of dunes originally administered by the Department of Conservation being vested in the District Councils (e.g. Coastal Recreation Reserves in Whakatāne District).

Other types of covenants and protection do not occur within the mapped dune vegetation.

6.1 What does legal protection mean?

The most important thing to note about legal protection is that it does not equal either physical protection for a site, or management to maintain a site. It is simply a designation over a parcel of land.

The type of reserve, and therefore degree of protection for dune land vegetation varies widely. Different reserve designations under the Reserves Act 1977 and the Conservation Act 1987 mean different things in terms of what activities can be undertaken on those reserves, and therefore whether or not infrastructure or other developments and activities that remove or potentially damage dune vegetation can occur.

Under the Reserves Act 1977, where values such as flora and fauna, historic, archaeological or biological features exist, the Act states that "those features shall be managed and protected to the extent compatible with the principal or primary purpose of the reserve". Local purpose reserves are specifically for the designated purpose at gazettal, and many reserves under administration by the territorial authorities are designated for specific activities such as landing reserves, sporting grounds, and playgrounds, amongst other things.

The Conservation Act is a little more specific under some designations, but not others. A Stewardship Area "shall so be managed that its natural and historic resources are protected". However a Government Purpose Reserve is designated for purposes "as specified in the designation of the reserve". Often these are Wildlife Management Reserves, but even this can cause some conflicts where wildlife management involves promotion of game birds over ecological values. Scenic Reserves look to protect indigenous flora and fauna, while promoting removal of exotic species. Marginal strips promote protection of adjacent water courses and bodies of water, as well as public access to those. Recreation Reserves are for open access, and primarily for "recreation and sporting activities and the physical welfare and enjoyment of the public, and for the protection of the natural environment and beauty of the countryside". All things being relative, neatly mown picnic areas might be preferred by some over pohuehue vineland. In addition, access, recreation and sporting activities can be extremely damaging to dune land vegetation and wildlife values.

District Councils are required to develop District Reserves Plans under Section 41 of the Reserves Act 1977, and these plans also determine to what degree ecological values are given regard to when they maintain reserve areas. Some districts place more emphasis on maintaining ecological values, while others acknowledge them but primarily focus on other aspects, meeting only the minimum requirement of the Reserves Act. A small Landing Reserve, for example, is unlikely to retain a lot of ecological character as its primary purpose is to provide a landing area.

Facilities for this will be developed at the expense of ecological values on the site where that specific area is required. Recreation and open space can also override ecological values where facilities are desired to provide for those things.

6.2 Reserve coverage of dune lands

Recreation Reserve (203 ha) and Government Purpose Reserve (194 ha) cover the largest area of the dune lands (See Appendix 5). Both designations are vague enough to have potential to promote other activities over biodiversity and ecological values. This highlights that legal 'protection' analyses often identify that an area is reserved, but do not always consider the purpose for which it is reserved and what that means for biodiversity values. Neither of these reserve designations provide physical protection across the board, and recreation reserve in particular, promotes full public access to those areas, placing ecological values as a secondary objective and therefore at constant risk. Emphasis on public access and use, or biodiversity, depends to some degree on the administering body, however the legislation clearly states that biodiversity and ecological values can be protected provided they do not compromise the primary purpose for which an area is reserved.

6.2.1 Ōpōtiki District

Ōpōtiki District is the only territorial authority (TA) that administers such a small proportion of the dune vegetation in its territory as district reserves. Of 392 ha, Ōpōtiki District reserves cover only 10 ha, or 2.4% of the dune land area in the Ōpōtiki District. These reserves are located at Ōhiwa Spit, and the rest of the district's dune lands have no reserve areas that cover the mapped dune land vegetation. Ōpōtiki District Council does own a reasonable proportion of the dunes near Ōpōtiki township that are not reserves, which provides a level of protection, but does not prevent development considered appropriate by the District Council as there are no reserves restrictions on those areas. They do not have Reserves Management Plans in place for their dune reserves at this stage (Mike Houghton, 2010 pers. comm).

6.2.2 Whakatāne District

Whakatāne District Council administers a little over a third of the dune vegetation in its territory, mostly as coastal recreation reserves from Ōtamarākau to the Rangitāiki River. This stretch of dunes is heavily used for recreation and access to fishing sites.

The Reserves Management Plans for this district are now aging and in need of updating. They address dune management and pest plant control in fairly general terms (Pete McLaren, 2010 pers. comm).

6.2.3 Western Bay of Plenty District

Western Bay of Plenty also administers very little, despite having the largest area of dune vegetation in the region, with 16.2% of the district's dunes in district reserves. Matakana Island does make up three quarters of the dune area for the Western Bay of Plenty district however, and the island is all privately owned with the exception of 80 ha at the southern end. The proportion of dunes administered outside of Matakana Island is 65.9% for the Western Bay of Plenty District Council.

The policies for reserve management in the Western Bay of Plenty District reserves management plans is variable and invokes the Reserves Act 1977 in terms of protecting natural values only where this is compatible with the primary purpose of the reserve. There is often a focus on the provision of open space in an amenity sense – open grass areas with shade trees and other basic facilities like picnic tables and toilets. Some of the reserves with these management priorities already exist to some extent and often exclude dune vegetation and any chance of restoring it, despite being on the dune landform. The concept plans do tend to maintain existing dune vegetation, but rarely, if ever, increase it.

On the positive side, working with Coast Care is often mentioned to resolve problems like vehicles and providing for pedestrian access, and to assist with dune revegetation. Kaituna Sand Spit Recreation Reserve[9] lists the development of an ecological restoration plan, and a few reserves include maintaining and enhancing the coastal reserve for protection of natural character and wildlife values. Natural character and ecological values are not ignored, but providing for access and use can, and does, override this in several cases.

6.2.4 Tauranga City

Tauranga City Council has the lowest area of dune land vegetation and administers 54.66% in their territory, with reserve areas stretching almost continuously from Mount Maunganui to the eastern end of Pāpāmoa's residential area. Most of their reserve areas abut housing and urban areas with a six kilometre stretch of undeveloped lands at the eastern end of their territory. Tauranga City Council has significant issues with encroachments of gardens and lawns being extended into the dunes. This is being addressed through the implementation of an encroachment policy. Their Coastal Reserves Management Plan (Tauranga District[10] Council, 1997) has several policies relating to pest plant management and the use of appropriate indigenous species which should result in improvements to the dune vegetation condition, as well as other management measures for avoiding further damage to dunes.

Table 3 Summary of dune land vegetation in reserves administered by Department of Conservation and District Councils.

District	Dune land Vegetation in District (ha)	Dune land Vegetation in District - District Reserves (ha)	% of Dune land Vegetation in District - District Reserves	Dune land Vegetation in District - DOC Reserves (ha)	% of Dune land Vegetation in District - DOC Reserves	Dune land Vegetation legally protected (ha)	% Dune land Vegetation legally protected
ODC	391.8	10.0	2.54	113.2	28.9	123.2	31.4
TCC	279.0	152.5	54.66	0	0	152.5	54.7
WBOP*	764.4 (187.8)*	123.7	16.12 (65.9)*	25.3	3.3 (13.5)*	149.0	19.5 (79.3)*
WDC	680.7	212.3	31.20	196.1	28.8	408.4	60.0
Total#	2115.7	498.5	23.6	334.6	15.8	833.1	39.4

***** Excluding Matakana Island
# Totals include Matakana Island

[9] Covers the spit that runs east from the mouth of the Kaituna River to the mouth of the Maketu Estuary.
[10] Still referred to as a District Council at that time.

Part 7: Vegetation change over the historic dunes landform

The historic dunes landform was mapped using Geological Survey Map of New Zealand field maps at 1:250,000 scale (Wildland Consultants, 2008a). These map historic fixed dunes as well as active dunes (at the time of mapping) based on geological landforms and soil types[11]. Based on this mapping there is 11,660 ha of historic dune landform in the Bay of Plenty region.

Overlaying vegetation cover mapping from the 1840 pre- and post-human vegetation, and the Land Cover Database 2 onto the historic dunes landform gives an indication of what sort of land and vegetation cover was present over that landform at that point in time. This will give an estimated picture of change over time so that we know what was there previously compared to what we have now. Note that these comparisons are fairly broad in nature but do generally characterise what existed at that time.

7.1 Vegetation over historic dunes landform at approximately 1840

The 1840 pre[12]- and post-human[13] vegetation layers are often used to indicate what sort of indigenous cover would have occurred over the landscape prior to Māori and European settlement respectively.

The 1840s vegetation layers do not include any exotic vegetation. Pre-European vegetation would have been more or less completely indigenous, and although the pre-human layer is based at 1840, it is a reconstruction of vegetation before human intervention. Following European settlement, introduced plants were starting to appear (Cockayne, 1909), but there was probably not the degree of naturalisation of exotic species that we have today. Cockayne's (1909 and 1911) accounts suggest that grazing and burning were a much greater influence on the dunes than exotic plants, although exotic plant species were starting to play a part and were becoming established on areas that had previously been burned and/or grazed in order to make the land more productive.

There is no information to suggest what type of vegetation constitutes the 1840 vegetation 'sand dunes' category, or whether this refers to open sand, active sand dunes in the early stages of colonisation, or low dune land vegetation. I have assumed the latter, that the 'sand dunes' category describes low dune land vegetation characterised by species such as spinifex, pingao, pohuehue and sand convolvulus. Forest was certainly a component of the dunes landform and would most likely have occurred in older stabilised dune areas behind the active dunes (Cockayne, 1911).

[11] Maps showing the extent of the landform are on the disc included in the back cover of this report.

[12] The pre-human vegetation 1840 layer provides a baseline reconstruction of what the natural vegetation is likely to have been in 1840 as it may have looked without human intervention. This dataset was developed partly from the post-human 1840 vegetation map, using the same areas of primary vegetation. The major difference is that the areas of secondary vegetation on the post-human 1840 map have been replaced with a representation of the primary vegetation likely to have been present if not previously cleared or modified. The likely character of the vegetation was determined by experienced ecologists, based on bioclimatic and landform character.

[13] Post-human 1840 vegetation reconstruction of the region (with human modification) depicting the likely former character of the vegetation. The map was compiled from a variety of sources, including historical accounts, old surveyors' maps, previously published vegetation maps and the informed judgment of experienced ecologists based on bioclimatic and landform pattern.

Having previously noted little variation in dune land vegetation throughout the country (although with some exceptions) Cockayne (1911) describes vegetation on dunes in evolution stages starting with low grassed developing dunes, through low vegetation and on to heath and scrub dunes as they become older and more stabilised, becoming forest at the last stage of being stabilised 'fixed' sand hills. Interestingly, even in 1909, Cockayne struggled to describe the typical vegetation that would have existed on the oldest areas of dunes, as it had already been changed by grazing, burning and introduced plants. Very few dune land areas in New Zealand have retained the sequence from low vegetation on the fore dune to scrub and forest in the older dune areas.

The 1840 vegetation layers are displayed in the figure below.

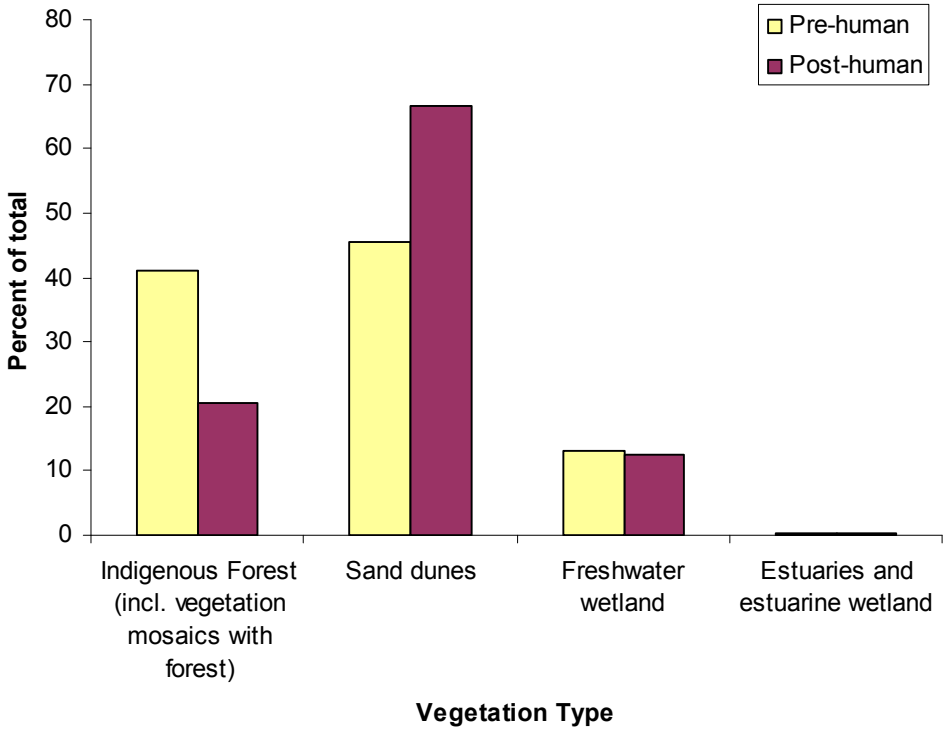


Figure 4 Vegetation cover of historic dunes landform at pre- and post-human 1840 (see footnotes 11 and 12 for data source).

The most significant feature of this figure is the shift from a relatively even split of area between sand dunes and forest in the pre-human landscape, to a majority sand dunes category post-human. The pre-human 1840 vegetation information indicates a much higher component of indigenous forest on the historic dune landform (41.2%) than the 20.4% remaining in the early European post-human era.

Note that the forest vegetation types have been combined to show the broad structural vegetation types here. The pre-human 1840 dataset separates forest into different types, describing them as forest types such as rimu/tawa forest (with kohekohe). The post-human dataset includes forest with other vegetation types - mosaic of forest (primary and secondary), shrubland, fernland, wetland; rimu/tawa forest (with kohekohe); tussock grassland, secondary forest, scrub, shrubland, and fernland. Only one is a pure forest vegetation type, so the 20.4% statistic is actually an overestimate of the actual forest present at that time.

The association of indigenous tall forest with old stabilised dune lands is unlikely to re-appear on dune landforms in the Bay of Plenty as the opportunities no longer exist, except over a very long geological time-scale.

7.2 Vegetation over historic dunes landform – Land Cover Database 2 (LCDB2) - (2001/2002)

The LCDB2 is “a thematic classification of 43 land cover and land use classes covering mainland New Zealand, the near shore islands and the Chatham Islands”. LCDB2 used Landsat 7 ETM+ satellite imagery for the summer of 2001/2002, and was released in 2004 (NZ Climate Change Office, 2004).

It is difficult to correlate the different categories in the 1840s vegetation layers and LCDB2 in terms of vegetation change on the historic dunes landform. The LCDB2 has far more divisions and the ‘sand dune’ category from the 1840s vegetation dataset can only be definitively related to the ‘coastal sand and gravel’ category in LCDB2. The 1840s vegetation does not define ‘sand dune’, while the LCDB2 clearly maps other land and vegetation cover types over those same areas. The LCDB2 categories have been consolidated to fit more closely with the 1840s vegetation categories, but this has considerable limitations and can only provide a broad picture of change.

What the LCDB2 does show very clearly is the shift to extreme dominance of human induced landscape features on the dunes landform that were completely absent in the 1840s datasets such as agriculture/horticulture, pine forestry and urbanisation, which are identified as occupying 82.1% of the historic dune landform in the Bay of Plenty. Note that the ‘low producing grassland’ category from the LCDB2 has been included with ‘coastal sand and gravel’ as it seems to fall mostly on the areas identified as remaining dune vegetation in the current 2009 exercise, suggesting that dune vegetation is what that category is identifying. Changes in the other categories such as forest, freshwater wetland and estuarine wetland can not be determined from this type of comparison between the datasets, and some of the changes would be artefacts of the different categories and mapping scales rather than actual change. I did not consider it appropriate to make any further comparisons between these two datasets.

A graph and table showing the expanded (original) LCDB2 is included as Appendix 6, with a brief discussion as to its comparability with the 2009 mapping exercise.

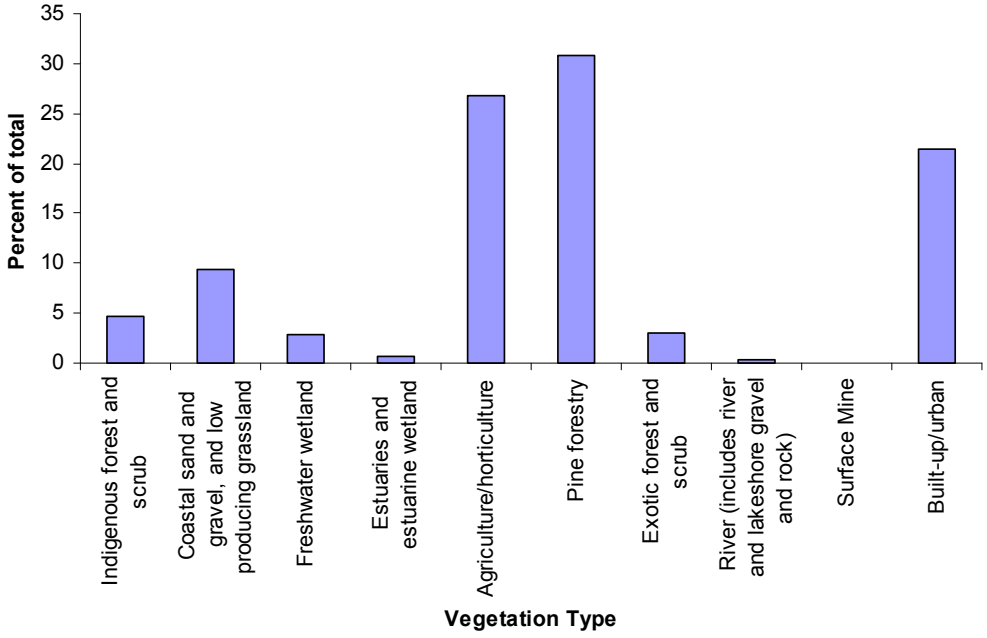


Figure 5 Land Cover Database 2 – Vegetation and land cover types at 2001/2002.

The key message from the comparison between the 1840s vegetation cover and the LCDB2 is the massive loss of indigenous dominant vegetation over the dunes landform and the shift to developed landscapes with little or no indigenous vegetation or biodiversity values.

7.3 Land cover over historic dunes landform – 2009

The land cover part of the 2009 mapping exercise used the historic dune lands landform as the base layer and mapped broad land cover types over the landform.

The current land cover on the dune lands landform was divided into seven categories:

- Plantation forest
- Wild undeveloped areas
- Agriculture/horticulture
- Residential and build up (includes commercial)
- Urban parkland
- Roads/parking areas/railway line

The categories aim to separate the anthropogenic landscape features from the remaining area that could be broadly considered to be dune land ecosystem. Firstly this tells us how much of the dunes have been developed. Secondly it highlights the areas where we still have some dune land biodiversity value which can then potentially be managed and enhanced to prevent any further loss.

Plantation Forest (30%) and Wild and Undeveloped (hereafter referred to as wild) (26%) areas had the highest percentage of the total cover. Figure 6 once again clearly shows the extreme dominance of anthropogenic features on the dune lands landform, with 74% of the total historic landform under some form of development or land use that excludes indigenous vegetation altogether. As mentioned earlier, this is slightly better than the national statistic of 89% of dune lands being lost. The LCDB2 estimates a slightly higher percentage of loss (82.1%); however the 2009 mapping is more accurate at a fine scale.

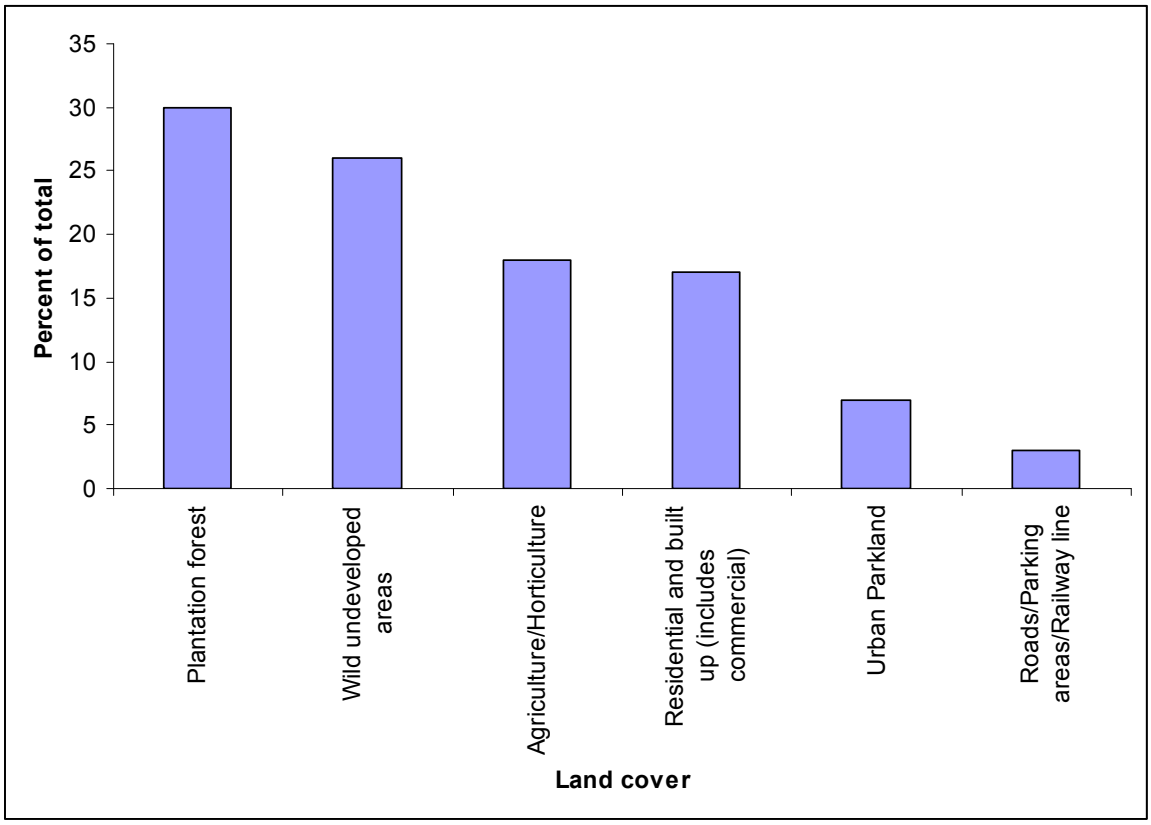


Figure 6 Current land cover over historic dunes landform (total 11,660 ha).

7.4 Vegetation on historic dunes landform – 2009

There are 3,005 ha (26% of the landform) of wild areas on the dunes landform in the Bay of Plenty region. Most of the remaining indigenous vegetation is of low stature, with very little or no scrub and dune land forest having been maintained. One area on the dunes that includes an understorey of indigenous coastal forest species has re-established under gum trees at Murphy's motor camp (just west of Matata), planted around 1920, since the last heavy burning and grazing episodes into the late 1980s and early 1990s (Wildland Consultants, 2007). It is not known which parts of the dunes these tall structural vegetation classes would have been present on in the past, but it is reasonable to suggest that there would have been a larger component of these types of vegetation on the dunes prior to human activity, both Maori and European. It is likely that most of these larger stature vegetation types would have been on the dune areas that are now developed, as the dunes remaining in the undeveloped state are generally the younger formations. The remaining dunes are more exposed to salt and wind and are less suitable for forest growth.

Comparing the LCDB2 with the mapped dune vegetation was also considered to look at changes between 2001/02 and 2009, but the LCDB2 categories can not be correlated to the categories of land cover mapped for the historic dune lands landform, and the differences of scale mean it would be inappropriate to do so in any detail (see Appendix 6).

In the vegetation mapping process, areas that were isolated or not contiguous with the area of dunes starting from the toe of the dune were not mapped. This has resulted in a difference of 887 ha in area between the 'wild' landform (3,005 ha) and the area of vegetation mapped (2,118 ha). The decision in the field on where to end the mapping was not always simple (Heather MacKenzie, 2010, pers. comm). Some of these areas include grass swards and other roadside vegetation separated from

the main areas of dunes by roads or areas of farmland. Although not clearly part of a developed land cover type, many lack indigenous character and from an ecological perspective add little value to the wild and undeveloped vegetation of the region's dune lands. There are a few exceptions to this rule, however further fieldwork will be needed to verify which should be included in the mapping and which are more appropriately left out. This is not considered important enough to warrant field assessment at this stage, and can be covered during the next mapping exercise. This work focuses on those areas of dunes that are contiguous from the toe of the fore dune to the next change in land use/cover (e.g. lawn, road, railway track, farm, grazing).

Vegetation with an indigenous component has been lost to nearly three quarters of the Bay of Plenty's dune area. We lack indigenous vegetation associated with older stable dunes. Those areas have been converted to forestry, agriculture/horticulture and urban areas. At a national scale there a very few dune lands that demonstrate the sequence of semi-vegetated unstable dunes to stable vegetated back dunes (Hilton *et al*, 2000) and the Bay of Plenty is no exception.

7.5 Vegetation structure and composition

As expected most (68%) of the vegetation mapped on the dunes was of lower stature. Forest, treeland, scrubland and shrubland (the only vegetation types here that would exceed 2 m in height) make up 32% of the total vegetation. It is important to note that within each of those categories of tall vegetation types, the indigenous dominated component is small, only 50.7 ha, or 2.2% of the total dune vegetation (see Appendix 7 and 8 for more detail of broad vegetation types in each structural class).

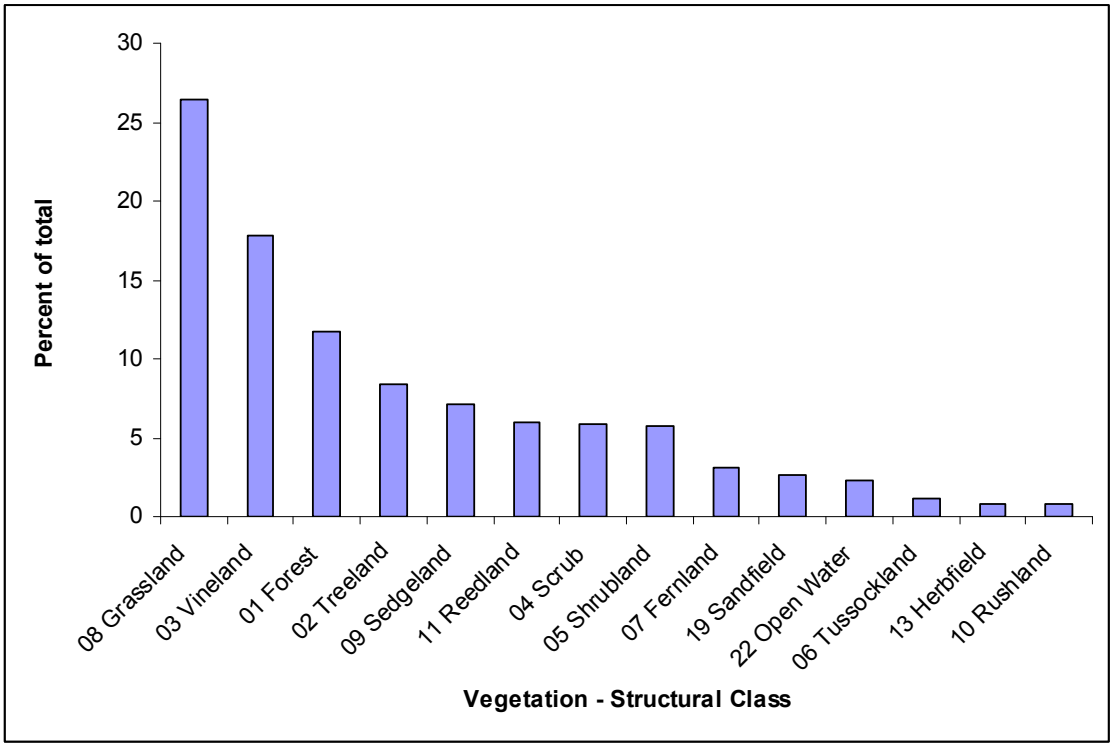


Figure 7 Percent of total mapped dune vegetation in each structural class.

Table 4 Vegetation types mapped on dunes in the Bay of Plenty region.

Structural Class	Vegetation Class	Area (ha)	Percent (%) of total area
01 Forest	01 Pine forest	229.34	10.83
	02 Banksia forest	0.80	0.04
	03 Willow forest	10.00	0.47
	04 Indigenous forest	8.28	0.39
		248.42	**11.73**
02 Treeland	01 Pine treeland	100.63	4.75
	02 Banksia treeland	39.11	1.85
	03 Eucalyptus treeland	18.76	0.89
	04 Silver poplar treeland	0.58	0.03
	05 Mixed exotic treeland	5.25	0.25
	06 Mixed indigenous treeland	9.65	0.46
	07 Pohutukawa treeland	3.53	0.17
	08 Macrocarpa treeland	0.55	0.03
		178.06	**8.41**
03 Vineland	01 Pohuehue vineland	373.97	17.66
	02 Cape ivy vineland	0.58	0.03
	03 Periwinkle vineland	0.05	0.00
	04 Japanese honeysuckle vineland	2.04	0.10
	05 *Muehlenbeckia australis* vineland	0.34	0.02
	06 Moth plant vineland	0.03	0.00
	07 Pink bindweed vineland	0.21	0.01
		377.21	**17.81**
04 Scrub	01 Mixed indigenous scrub	14.76	0.70
	02 Gorse scrub	72.22	3.41
	03 Coast tea tree scrub	9.85	0.47
	04 Grey willow scrub	26.74	1.26
	05 Blackberry scrub	0.25	0.01
	07 Manuka scrub	0.21	0.01
		124.03	**5.86**
05 Shrubland	01 Manuka shrubland	1.48	0.07
	02 Ti kouka-taupata shrubland	0.45	0.02
	03 Lupin shrubland	15.39	0.73
	04 Gorse shrubland	11.40	0.54
	05 Coast tea tree shrubland	27.49	1.30
	06 African boxthorn shrubland	11.38	0.54
	07 Grey willow shrubland	40.82	1.93
	08 Coastal kanuka shrubland	9.62	0.45
	09 Saltmarsh ribbonwood shrubland	1.53	0.07
	10 Kanuka shrubland	0.59	0.03
	11 Mixed indigenous shrubland	0.63	0.03
		120.76	**5.70**
06 Tussockland	01 Sea rush tussockland	4.27	0.20
	02 Pampas tussockland	20.72	0.98
		24.98	**1.18**
07 Fernland	01 Bracken fernland	66.23	3.13
		66.23	**3.13**

08 Grassland	01 Spinifex grassland	190.84	9.01
	02 Marram grassland	65.37	3.09
	03 Buffalo grass grassland	8.06	0.38
	04 Kikuyu grassland	30.76	1.45
	05 Cocksfoot grassland	32.72	1.55
	06 Knot-root bristle-grass grassland	2.02	0.10
	07 Tall fescue grassland	70.56	3.33
	08 Sea couch grassland	143.21	6.76
	09 Reed sweet grass grassland	3.01	0.14
	10 Indian doab grassland	7.40	0.35
	11 Saltwater paspalum grassland	5.98	0.28
	12 Smooth brome grassland	0.33	0.02
	13 Rats tail grassland	0.23	0.01
	14 Hares tail grassland	0.13	0.01
	15 Ripgut brome	0.08	0.00
		560.69	**26.47**
09 Sedgeland	01 Pingao sedgeland	0.69	0.03
	02 *Carex testacea* sedgeland	42.19	1.99
	03 *Ficinia nodosa* sedgeland	69.94	3.30
	04 *Baumea juncea* sedgeland	22.02	1.04
	05 Giant umbrella sedge sedgeland	9.00	0.42
	06 *Carex pumila* sedgeland	2.08	0.10
	07 *Baumea articulata* sedgeland	2.83	0.13
	08 *Carex geminata* sedgeland	0.25	0.01
	09 Marsh clubrush sedgeland	0.85	0.04
		149.85	**7.08**
10 Rushland	01 Oioi rushland	14.31	0.68
	02 Wiwi rushland	2.87	0.14
		17.18	**0.81**
11 Reedland	01 Raupo reedland	127.20	6.01
	02 *Schoenoplectus tabernaemontani-Baumea articulata* reedland	0.42	0.02
		127.62	**6.03**
13 Herbfield	01 South African iceplant herbfield	2.30	0.11
	02 *Gazania linearis* herbfield	8.55	0.40
	03 Flatweed herbfield	2.01	0.10
	04 Mixed exotic herbfield	2.36	0.11
	05 *Asparagus densiflorus* herbfield	0.09	0.00
	06 *Agapanthus praecox* herbfield	1.20	0.06
	07 Canna lily herbfield	0.01	0.00
	08 *Rorripa palustris* herbfield	0.24	0.01
	09 *Aster subulatus* herbfield	0.42	0.02
	10 Panahi herbfield	0.82	0.04
		18.00	**0.85**
19 Sandfield	01 Sandfield	55.59	2.62
		55.59	**2.62**
22 Open Water	01 Open water	49.24	2.33
		49.24	**2.33**
GRAND TOTAL		**2117.86**	**100.00**

Across the structural classes, vegetation described as being characterised by indigenous or exotic species each covered about half the dune land area. Based solely on the vegetation type descriptions it is impossible to determine to what extent the vegetation types are dominated by exotic species, and what the indigenous component is, but because vegetation descriptions use the most prominent species, it does suggest that exotic species are prominent over half the dunes in the region.

On a landform basis, the vegetation did not show anything unexpected, in the sense of unusual associations of vegetation types on different types and parts of the dunes. In the mapped vegetation the landforms were as follows (see Appendix 9 for definitions).

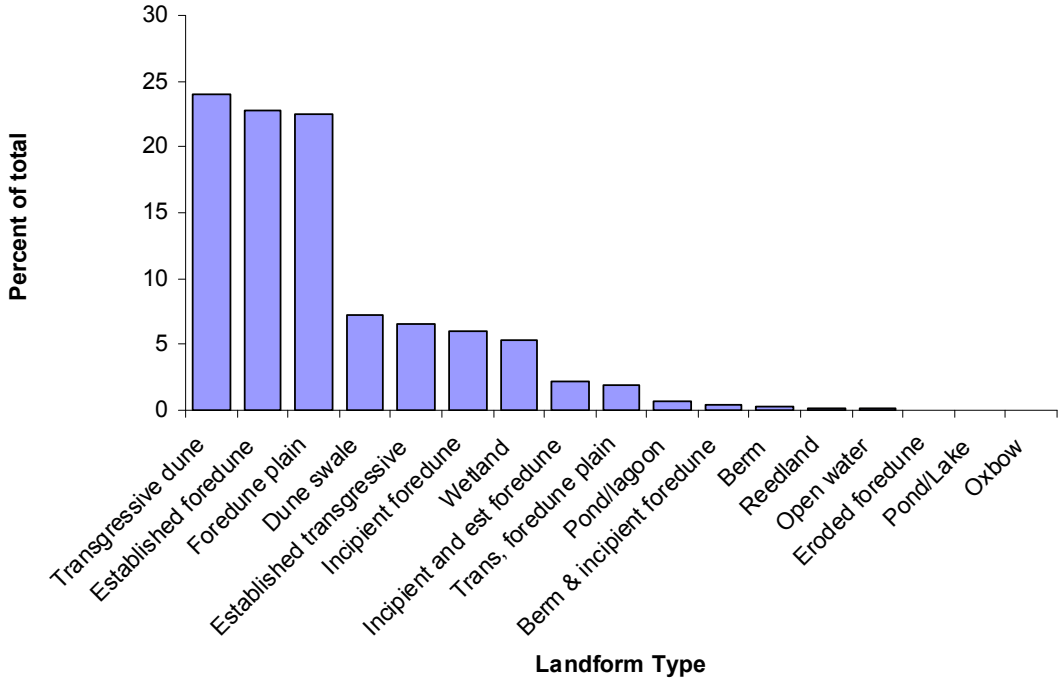


Figure 8 Percent of landform type in mapped vegetation (see Appendix 9 for landform definitions).

The berm was mostly (88.8%) spinifex grassland and sandfield, and the incipient fore dune, the site of dune building, was more than half spinifex dominated vegetation types, including spinifex-pingao-sand convolvulus grassland. These are the species that would be expected on this part of the dune. The more established dunes were more variable. The established fore dune included 106 of the 184 vegetation types found in the dunes, and no one vegetation type covered more than 8% of the established fore dune area. The only structural class that did not occur on this landform was forest. The fore dune plain was similarly variable, but lacked any herbfield vegetation. The highest cover was attained by pohuehue-bracken vineland at 14.4% of the landform. Dune swale and wetland areas also showed the expected vegetation types, with wetland species more prevalent. Over half (59.8%) the wetland landform had willow dominant vegetation types. Transgressive dunes had a higher component of pine forest (35.0%), reflecting the dominant landform of Matakana Island, but were otherwise also quite variable. Established transgressive dunes, where a transgressive dune has become more stable, were a little over a third (35.4%) pohuehue-knobby clubrush vineland and included 20.0% manuka-mixed indigenous shrubland. The remainder of the area included several structural classes but with lesser coverage.

There was no estimate of exotic species cover at the site level. Estimating cover becomes more difficult as a site becomes larger, so while a useful indication, the estimates would have provided only a broad idea of exotic cover across the sites. This is why transects were used to estimate at a finer scale.

The transect mapping included an estimate of total pest plant cover in each vegetation polygon. Note that there is often a distinction between the pest plants listed and estimated, and exotic vegetation, so this figure does not always represent the total exotic species. Taking an average pest plant cover estimate for each transect (by calculating the average of the estimates for each polygon within that transect), shows that there is a high component of pest plant and exotic species in most of the transects. Half the transects had an average exotic cover between 25% and 50%. An average estimated exotic cover over 50% was found on 9.1% of transects. Estimated exotic cover averaged 30.1% for all the transects in the region. The addition of an overall estimate of pest plant and exotic cover for the transect as a whole would be worth adding to the data collection.

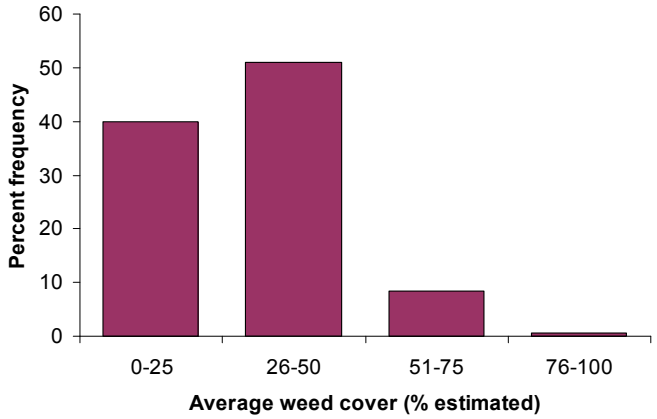


Figure 9 Percent frequency of pest plant and exotic cover by transect.

This estimate is only semi-quantitative, and doesn't necessarily include all exotic species, but it does give an idea that the character of the dunes is still a little more indigenous than exotic. The emphasis is on 'a little'. We tend to see the dunes as wild without distinguishing exotic or indigenous vegetation, unless the exotic species is very prominent, such as bright flowering gazania, or big clumps of pampas with their obvious flowering heads. However smaller species such as harestail and hawksbeard can still dominate areas of the dunes and prevent regeneration of indigenous species, just not as noticeably as pampas. And exotic grasses still change the composition and structure of the vegetation.

A flaw of this data set is that it lacks more quantitative vegetation cover data, however the methods that might be applied still have a semi-quantitative component and would need careful consideration as to whether the extra effort and resources required is worth the additional data for regional council needs.

7.6 Threatened and significant plants

The Bay of Plenty sand dune vegetation includes a number of threatened species, including one nationally vulnerable species – Thornton kanuka (*Kunzea* aff. *ericoides* (Thornton)) - that is endemic to the Bay of Plenty and has a very limited distribution. This mapping exercise estimates the cover of these species both in each polygon of each transect and for each site as a whole. Some species, although not threatened, are significant because they are regionally uncommon, reach their natural distributional limit, or are an unusual or unique association.

The transects do not always pick up plants that have scattered and small populations across the region, so that their presence on the transects and in sites is still likely to slightly underestimate the true population present on the region's dunes. It is not possible to identify every population of every threatened or significant species, simply because the methods aim to provide a bigger picture and do not call for detailed counts and searches for threatened species. The recording of these species by site as well as transect, does fill in some of the gaps. *Austrofestuca littoralis* is a case in point, where the transects miss the largest population in the Bay of Plenty at SDVC-013, Kaituna Sand Dunes. Its presence is identified in the site information. Coastal grasses can be difficult to distinguish where flowers and/or seed heads are not present, so some of the grass species may be underrepresented in the data because they were unable to be identified. And some plants may have simply remained unseen during the field work.

For the purposes of the dune lands NERM monitoring, it is sufficient to know that these species remain present on the dunes, and closer attention can be paid as part of operational programmes, of dune restoration as part of Coast Care or the Biodiversity Programme, and by collaboration and information sharing with other organisations such as the Department of Conservation. This monitoring will be able to detect range expansion of plant species because they should begin to appear in the data on more transects and/or in more sites, at higher cover levels, but is unlikely to provide a lot of detail about the size of the population or numbers of plants. Cover estimates for a site mean that most of the threatened plants only achieve the lowest cover class estimate, however the transect cover estimates may provide limited indication of increasing population size where threatened and significant plants start to increase their cover in a particular vegetation polygon. As with exotic and pest plants, it may be useful to estimate their cover across a whole transect in the future.

Table 5 Threatened and significant plants found on dunes in Bay of Plenty region.

Species – Latin name	common name	Threat ranking[14]	No. Transects (% of transects)	No. Sites (% of sites)
Kunzea aff. *ericoides* (Thornton)		Acutely threatened, nationally vulnerable	4 (2.4)	1 (2.4)
Austrofestuca littoralis	hinarepe	At risk, declining	8 (4.8)	8 (19.0)
Coprosma acerosa	sand coprosma	At risk, declining	9 (5.5)	2 (4.8)
Cyclosorus interruptus		At risk, declining	6 (3.6)	3 (7.1)
Euphorbia glauca		At risk, declining	0 (0.0)	1 (2.4)
Pimelia villosa subsp *arenaria*	sand daphne	At risk, declining	4 (2.4)	2 (4.8)
Apium prostratum subsp. *denticulatum* var. *filiforme*	NZ celery	At risk, naturally uncommon	1 (0.6)	1 (2.4)
Melicytus novae-zelandiae		At risk, naturally uncommon	3 (1.8)	2 (4.8)
Tetragonia tetragonioides	kokihi	At risk, naturally uncommon	6 (3.6)	3 (7.1)
Ficinia spiralis	pingao	At risk, relict	81 (49.1)	20 (47.6)
Carex pumila		Not threatened	90 (54.5)	18 (42.9)
Carex testacea		Not threatened	25 (15.2)	4 (9.5)
Coprosma repens	taupata	Not threatened	35 (21.2)	10 (23.8)
Haloragis erecta subsp. *erecta*	toatoa	Not threatened	1 (0.6)	1 (2.4)
Lachnagrostis billardierei	perehia	Not threatened	154 (93.3)	21 (50.0)
Metrosideros excelsa	pohutukawa	Not threatened	16 (9.7)	7 (16.7)
Myoporum laetum	ngaio	Not threatened	8 (4.8)	5 (11.9)
Oxalis rubens		Not threatened	96 (58.2)	18 (22.9)
Ozothamnus leptophyllus	tauhinu	Not threatened	16 (9.7)	8 (19.0)
Senecio biserratus		Not threatened	2 (1.2)	1 (2.4)
Senecio glomeratus		Not threatened	1 (0.6)	1 (2.4)
Zoysia pauciflora		Not threatened	42 (25.5)	9 (19.0)

Several species were widespread across the region, including pingao, taupata, *Oxalis rubens, Ozothamnus leptophyllus* and perehia, although not always at high densities in terms of their presence on the transects. For example *Oxalis rubens* was found on 58.2% of the transects throughout the region. While *Ozothamnus leptophyllus* was also spread across the region it occurred at far fewer transects (9.7%). Perehia was the most frequently recorded species on 93.3% of the transects, in 50% of the sites. It was however, found on only three transects east of Whakatāne. *Carex testacea* was also not recorded in the eastern part of the region, with its distribution stopping at Ōhope Spit, and *Coprosma acerosa* was only found on transects west of Maketū.

Pingao was found on transects right across the region, occurring at nearly every transect between Mount Maunganui and Kaituna spit, and with lesser frequency outside that area. Pingao is widely used in Coast Care plantings, however its presence on the transects did not necessarily relate to areas mapped as being under active management by Coast Care. Its status as 'At risk, relict[15]' indicates that it is a species with populations vastly reduced from their pre-human numbers and distribution.

[14] de Lange *et al*, 2009

[15] Relict = taxa that have undergone a documented decline within the last 1000 years, and now occupy less than 10% of their former range. Takes into account the area currently occupied as a ratio of its former extent. (Townsend *et al*, 2008).

Several species had very limited distributions based on the transects. *Cyclosorus interruptus*, a wetland species, was found only on transects in the northern wetlands of Matakana Island. These are the only significant areas of wetland recorded in the dune lands mapping, although smaller areas do exist in the Ōtamarākau-Whakatāne stretch, and around Tirohanga and Omarumutu east of Ōpōtiki, so this is neither an unexpected result, nor of great concern in this context.

Toatoa was found only at the end of Maketū Spit, and both *Senecio biserratus* and *Senecio glomeratus* were found at one transect on Matakana Island. New Zealand celery was found only at Orokawa Bay, although it is known to be present near Mount Maunganui, at Waiotahi Beach, Bryans Beach and several other East Cape sites (de Monchy, 2010 pers. comm). Of these species, only New Zealand celery is threatened.

As expected, Thornton kanuka was found only on transects between the Tarawera and Rangitāiki Rivers, although it is present as scattered clumps and individuals all the way from Tarawera River to the Whakatāne River. The full extent of Thornton kanuka was not recorded here because some of it occurs as remnant clumps in farmland. This species is of particular importance because it is endemic to the Bay of Plenty, so that we have a responsibility to maintain this at a national level. The greatest threats to Thornton kanuka are clearance and fragmentation from subdivision and housing, and grazing.

Melicytus novae-zealandiae was recorded on Matakana Island and at Pāpāmoa, however there was a problem with mistaken identification of this species by field staff and its true distribution has not been recorded. It has recently been confirmed immediately west of the Thornton motor camp (Mieke Kapa, 2010 pers. comm), which is the main population, and it can be found scattered further west as far as the Tarawera river (Paul Cashmore, 2010 pers. comm), despite it not being recorded for that site or on any of the transects within that site. If *Melicytus novae-zealandiae* is recorded at more sites, or on more transects, in the next monitoring and/or mapping period it should not be taken as range or population expansion in the sites from Ōtamarākau east.

Pohutukawa is not a threatened species, but it does contribute significantly to the Bay of Plenty's natural character. Although relatively widespread around the region, pohutukawa does not appear to occur on the dune lands landform with a great deal of frequency, and personal observation shows it to occur more on and around cliffs, and up on the hillsides of limited parts of the coastal zone rather than on the dunes themselves. It was notably present on all the transects that occurred within the extent of the *Eucalyptus* forest areas around Murphy's motor camp, near Matatā. In this area indigenous coastal forest species have established under the *Eucalyptus* canopy, and a reasonably diverse range of species, including pohutukawa, have established (Wildland Consultants, 2007). This is one of the only places in the region that has any forest or scrub occurring on the dunes.

Pohutukawa was encountered on 9.7% of transects and only occurs as a component of the vegetation types at Waiotahe in the eastern Bay of Plenty. Forest including any indigenous species was found to be quite rare on the existing undeveloped areas of the dunes, with the vast majority of the forest structural class being the pine forest on Matakana Island.

7.7 Cover of Exotic Plant Species

This was measured by estimating the percent cover of each pest plant species in each vegetation polygon. The cover over the entire transect was also measured.

7.7.1 Spatial distribution and diversity

In looking at the spatial distributions of pest plants, there does not appear to be a strong pattern. For example we might expect to see the highest levels of pest plant cover occurring near areas of high population, with lower levels along parts of the coast where housing is sparse and well scattered. This doesn't appear to be the case. Fifteen transects had more than 50% average pest plant cover[16]. Of those, the adjacent land use was residential housing at six, undeveloped land at five, two were next to the Ōhope golf course, one was adjacent to forestry on Matakana Island and one ran from the railway to the beach at Ōtamarākau. Transect 9 has an average pest plant cover of 9%. It is located 1 km from Transect 10 which has an average pest plant cover of 50.2%. Both are in front of residential housing at Central Waihī Beach. All of these examples indicate that residential housing is not necessarily the cause of high pest plant cover.

Table 6 Transects with 50% or more estimated pest plant cover. Based on average pest plant cover at each transect.

Transect No.	Average pest plant cover	Location	Adjacent land use
007	87.8	Waihī Beach – near Wilson Road	Residential housing
010	50.2	Waihī Beach – southern end of Island View	Residential housing
019	58.5	Matakana Island – northern end	Forestry (*Pinus radiata*)
042	62.5	Mount Maunganui – Marine Parade between Sutherland Ave and Tay Street	Residential housing
043	50.0	Mount Maunganui – Marine Parade off the end of Hart St	Residential housing
080	62.5	Pukehina – near the southern end of Pukehina Parade	Residential housing
088	55.1	Ōtamarākau – slightly south of Waitahanui Stream mouth	Railway, none
125	52.0	Opihi – between Coastlands and Whakatāne R	none – land undeveloped
126	52.3	Just west of Piripai Spit, Whakatāne River mouth	none – land undeveloped
135	50.2	Ōhope – between Te Akau Street and Maraetōtara Stream	Residential housing
141	50.2	Ōhope – western end of golf course	Golf course and reserve
142	50.6	Ōhope spit – eastern end of golf course	Golf course and reserve
153	60.5	West of Waioeka River mouth	none – land undeveloped
156	53.1	East of Ōpōtiki – Snell Rd beach access	none – land undeveloped
263	56.7	Whangaparaoa – Waitewake Stream	none – land undeveloped

[16] Each polygon that is mapped on the transect has an estimated percent weed cover. This uses the average weed cover of the polygons mapped at each transect.

In looking at areas of low pest plant cover (<10%), there did appear to be more of an association with areas with little development. Twenty two transects had an average pest plant cover of <10%, with only five of those transects located adjacent to areas of residential housing. Most of them were in areas of undeveloped land, with some rough pasture, or with the transect extending inland to be stopped by rail or road.

Equally, however, the rest of the spectrum of average pest plant cover are all broadly scattered across the region, so that no one particular land use is associated with particularly high or low pest plant cover.

The average across the region is 30.1% estimated pest plant cover on the transects, indicating that invasion by exotics is widespread and most of our dunes are nearly one third exotic. On the positive side, this also indicates that our dunes are still more or less dominated by indigenous species. This is not to say, however, that we can relax our efforts in pest plant control in dunes around the region.

Diversity of pest plant species might also be expected to be related to higher population and/or residential housing, and there was a tendency for transects with a higher average[17] number of species to be those in front of housing areas at Ōhope, Mount Maunganui and the length of Pāpāmoa, and Waihī Beach. The five transects with the highest average number of pest plants were well within residential areas and Ōhope Beach had the dubious distinction of appearing to be the most weedy beach in the region with five of the six transects along the residential zones from east of West End in the top ten average counts, with 10 or more species. Notably, however, some of the higher counts occurred on Piripai and Ōhope spits. Both these areas are off the end of housing areas, rather than directly in front, but both areas are reasonably heavily used. The high counts may be due to the combination of heavy use and that they are out of the way, so that administering bodies do not often inspect them. They may not be considered major recreation areas (Ōhope Spit is a Wildlife Refuge), and therefore there is little incentive to do extensive pest plant removal work. In addition, these sites are open to continuing invasion from surrounding seed sources and because they are reasonably large, a detailed survey would be needed to adequately map pest plants and establish a systematic control programme. Some exotic species may not be prominent or of major concern, and once the prominent pest plants such as pampas and gorse have been removed, attention for management activities may be diverted elsewhere.

In the eastern parts of the region, transects with more than an average of five pest plant species seemed to occur at more prominent access sites such as the mouth of Waioeka River, Waiotahi Beach, Oruaiti and Whangaparaoa. Transects with an average of less than five species conversely fell in the areas where dense housing was absent, such as Matatā Straights and the coast from Matatā township to Coastlands, Matakana Island and the area between Pāpāmoa's eastern end and the end of Maketū Spit, and most of the transects east of Ōpōtiki. The median number of pest plant species per transect was 4.25 and the maximum was 13. The highest number of pest plant species found in any one polygon on a transect was 21, on a transect each at Ōhope, and Ohiwa Spit.

It is important to note that there are exotic species in the dune lands, and then there are pest plants. Some are more serious than others. For example, harestail is common throughout the dune system but does not dominate in the same way as other species and is not considered a major threat. Lupin was a major threat to dune lands, both in terms of absolute cover and in their nitrogen fixing ability, which changes the nutrient status of the dunes making them more available to other exotics, which tend to out-compete indigenous dune plants.

Approximately 25 years ago they were struck by a fungus outbreak (anthracnose blight) which has severely impacted lupin (Des Pooley, 2010 pers. comm), so that the plants that are found on the dunes now are scattered, sick and mostly less than a metre tall. Lupin is no longer a major threat and does not warrant major efforts to control or eradicate. Other species such as African boxthorn, pampas, *Smilax*, kikuyu grass, and *Agapanthus*, amongst others, now pose a more major threat, capable of dominating large areas of dunes, dominating the seed rain, out-competing and excluding native species and becoming drivers of processes of succession. They are pest plants and need to be controlled if we are to maintain our dune land ecosystems into the long term. There are significant cost implications to be worked through if this is to be achieved.

7.7.2 Spatial distribution of specific pest plant species

Wildland Consultants (2008b) describes the mapping of the dune lands and also lists management priorities at each transect, as well as management actions based on pest plant species. They list a number of pest plant species that they consider to be a major threat to dunes for various reasons and the spatial distribution (based on transects) of those species is examined here.

Eradication will not be feasible for most species, but looking at spatial distribution can aid management decisions. Widespread species will require different management tactics and probably long term programmes, while eradication may be possible for species with limited distributions. Discussing pest plant control techniques is outside the scope of this report; however management strategies may be suggested and discussed.

Coastal tea tree

This species was introduced to Matakana Island about 80 years ago to provide a protective buffer from wind and salt for the pine plantations on the island. Coastal tea tree is an eastern Australian plant which has become a problem in western Australia and South Africa where it has also been planted on dune lands (Walter Stahel, 2010, pers comm). In western Australia it has spread rapidly from plantings following sand mining.

Coastal tea tree is available in nurseries as a garden plant, but was not mapped as a part of the vegetation[18] in any other part of the region. On Matakana, coastal tea tree forms the canopy except where it occurs under pines, and is an element that would not normally be found on the Matakana Island fore dunes .

Coastal tea tree is considered a serious threat to dune vegetation (Wildland Consultants, 2008b). Its distribution remains restricted to Matakana Island, and continuing the existing ongoing campaign with a long term view to eradication may be possible. Longevity of seed bank may require long term monitoring to eliminate seedlings.

[17] On transects, weed species were identified in each polygon. Therefore the average number of species was calculated for each transect.

[18] Vegetation mapping follows Atkinson (1985). This method lists dominant canopy species first and then species in the lower vegetation tiers. A species with less than 20% estimated cover is included in these types of descriptions only if there are no species that reach the 20% cover level in that tier, or if they are “conspicuous” (e.g. rata emergent over the main forest canopy). Features such as underlining, brackets, hyphen, back slash are used to indicate estimated percent cover, whether species occur in the same tier or form a canopy over another species.

Figure 10 Distribution of Coastal Tea Tree.

Kikuyu grass

Kikuyu is widespread across the region, appearing in 38% of the transects. It is present as a component of the vegetation across some 59 ha (3%) of the total dune area. Matakana Island has only two transects with kikuyu present, and vegetation mapping of the Matakana Island sites do not list kikuyu as a feature of the vegetation type. Although this doesn't mean kikuyu isn't present there, it does suggest that it is only a minor feature of the vegetation and may be confined to localised areas. This also means that eradication may be possible, unless it is common on Rangiwāea Island. If this is the case, it is likely that it will eventually become widespread.

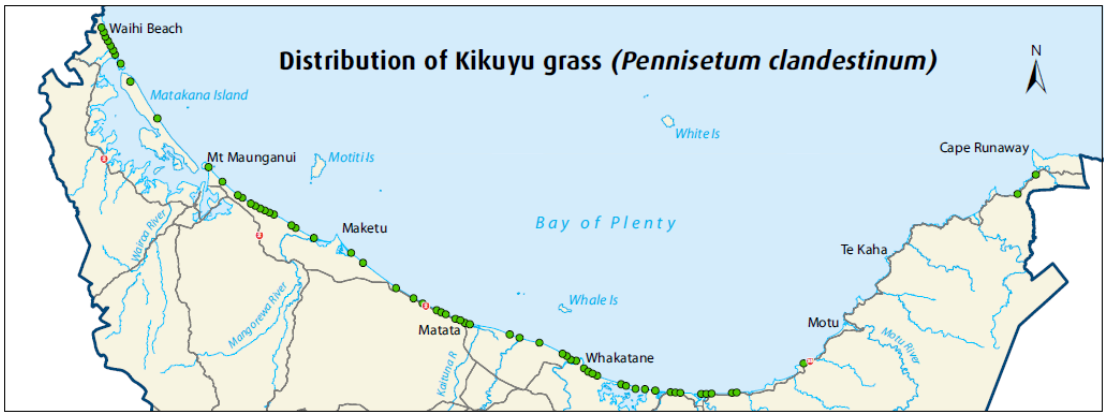


Figure 11 Distribution of Kikuyu grass.

Kikuyu does not 'fit' the dune character, being dense and bright green, in contrast to New Zealand's more subtle shades of dune-binding species. Although sometimes perceived to be beneficial in stabilising dunes, kikuyu is not very salt tolerant, will not extend to areas exposed to salt spray, and it does not trap sand as well as our native species. It is probably impossible to eradicate kikuyu due to its widespread use in grassed areas around the coast; however its management in most dune areas would be beneficial in maintaining the indigenous character of sand dune vegetation (Wildland Consultants, 2008b). Where environmental conditions are favourable kikuyu will scramble over and completely smother most things it encounters, plants included. Native species that can best combat kikuyu include dense flax and vigorous pohuehue.

Figure 12 Pohuehue vineland – the density of the growth prevents the establishment of most other plant species and provides valuable habitat for invertebrates and lizards.

Figure 13 Contrast of bright green kikuyu against silvery grey spinifex grassland.

An assessment of whether or not an annual programme of work is feasible to maintain a line of defence between lawn and grassed areas and dune areas may be worthwhile.

Marram

Marram was widely used in NZ for dune stabilisation and it was noted very early in the piece that marram causes dunes to be taller and steeper than our native sand binding species (Cockayne, 1909, Esler, 1970). This results in bigger blowouts and very steep dune faces during an erosion event. Dunes naturally go through a cycle of erosion, re-building and stabilisation, which maintains the fore dune as a protective barrier (Hesp, 2000). However marram interrupts this process by forming a dense cover that reduces dune instability (the erosion part of the cycle), and accelerates vegetation succession by stabilising the dunes. This means that phases of rebuilding that provide opportunities for native specialist sand binding plants are reduced as well (Hilton *et al*, 2000) and the vegetation processes on the dunes are altered from their natural course. Marram may also out-compete native species, both sand-binding fore dune and other species such as sand tussock (Kellett, 2008).

Despite all these things, marram was still used extensively around New Zealand to stabilise dunes, especially in the larger dune fields around the country, and has become a common element in the Bay of Plenty's dunes, although how much was planted is unknown.

Marram occurs on 37 transects (22%) across the region, mostly west of Whakatāne. There is no indication from the spatial distribution that marram was planted in a systematic way around the region, as it is not specifically associated with anything like housing or other structures. It seems to appear more often in the vegetation mapping in areas away from housing. Some may not have been deliberately planted, however de Monchy (2010 pers comm.) noted new plantings between Pukehina and Otamarakau. Marram was used in parts of the country to try and prevent dunes from wandering onto productive farm and cropping areas, but the Bay of Plenty doesn't appear to have had any mobile dunes that would warrant this kind of action.

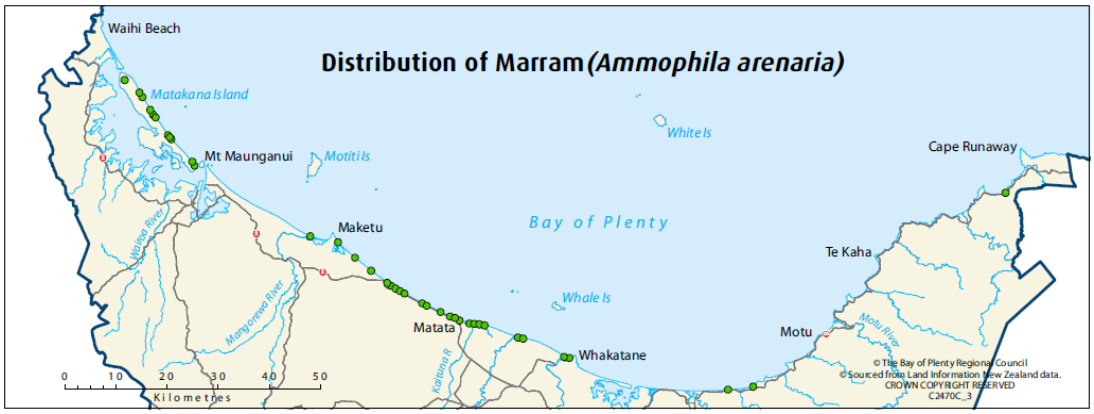


Figure 14 Distribution of Marram.

Although dominant on some transects, with cover estimated to be over 75% in some, it does not appear to dominate large tracts of the dunes, and progressive removal may still be a management option. It is currently found in vegetation types that cover 76 ha (3.6%) of the dunes. There is no work being done to remove marram from the dunes, although some removal is planned for Maketu Spit through the Biodiversity Programme (discussed in Chapter 8). Although marram is likely to occupy the same areas of fore dune that spinifex and pingao also occur in, Coast Care works do not remove marram as a rule and tend to plant around it due to budget constraints[19] (Pim de Monchy, 2010 pers comm).

Pampas

Pampas was found on 83 transects (50%) making it the most commonly found pest plant on the dunes. Pampas is an extremely widespread pest plant in the region as a whole. It favours open, recently disturbed soils, produces very high numbers of wind-blown seeds and is capable of excluding all else. It is often transported in sediments transported from already infested areas. Events like the 2005 Matatā flood event provided large areas of new ground that were quickly infested by pampas. It appears to be tolerant of a wide range of conditions. Pampas is commonly associated with pine plantations where harvesting and road building provide ideal conditions. It is no surprise that pampas is found on all the transects on Matakana Island, where pampas is a widespread issue.

[19] Coast Care volunteers and contractors have a limited capacity and budget to carry out comprehensive pest plant control. Weeds are controlled to prepare new sites and to release newly planted seedlings. More widespread ecological weed control is being increased, but will require a major increase in resource to make significant improvements in the dunes across the region (Pim de Monchy, 2010 pers comm).

The spatial distribution shows that pampas is much less common in front of residential areas, but occurs frequently on more isolated parts of the coast, such as Maketū Spit, Ōtamarākau-Matatā-Whakatāne, Ōhope Spit, between Ōhiwa Spit and Ōpōtiki, Tirohanga, Ōmaio and Whangaparaoa.

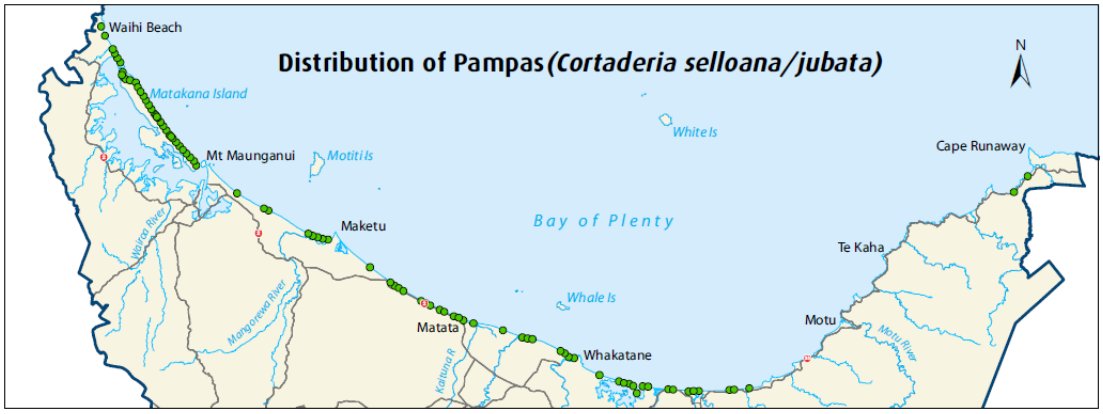


Figure 15 Distribution of Pampas.

Pampas is another species that is very visually prominent on the dunes. Unfortunately it is also so widespread throughout the region that eradication is no longer feasible. This means that keeping it under control on the dunes will be a permanent feature of dunes management unless a very effective biological control is found.

South African iceplant

This plant hybridises with and replaces the native ice plant (*Disphyma australe*). South African iceplant forms mats over sand dunes and other open areas displacing other vegetation. It changes the structure of sand dunes by preventing sand movement and altering the natural processes of disturbance and change in dune environments. It also reduces soil pH, influences soil nutrients, and can build a layer of organic matter in normally sandy soils, which allows other non-native species to establish (Weedbusters website, 2010).

South African iceplant appears on 50 (30%) of the transects, mostly at low densities. The vegetation mapping includes it in vegetation types that cover 150 ha (7%) of the region's dunes. This species appears to have a strong association with residential housing, although it does occur in some areas that are not adjacent to housing. In the vegetation mapping the bulk of the vegetation types where it occurs are in front of residential areas at Waihī, Pukehina and Ōhope. It occurs on nearly all the transects in front of residential areas at Waihī, Mt Maunganui, Pāpāmoa, Pukehina, and Ōhope.

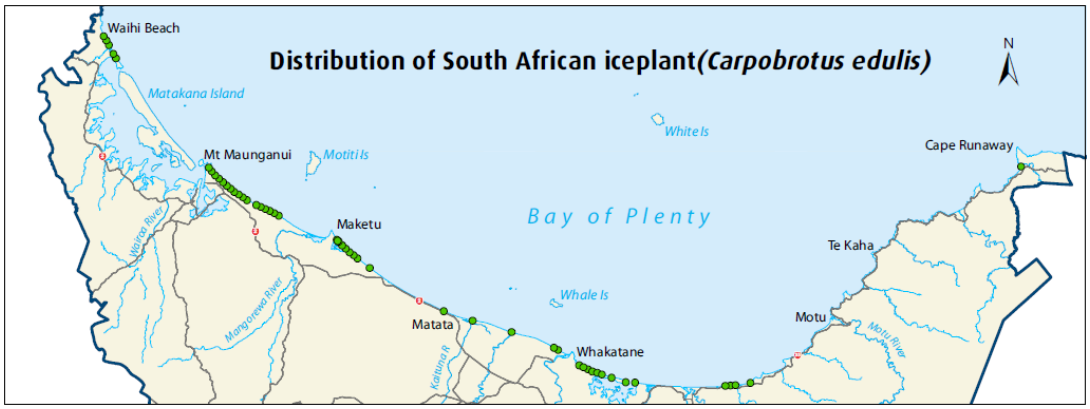


Figure 16 Distribution of South African iceplant.

Figure 17 South African iceplant on the foredune at Murphy's Motorcamp near Matata – it is not a specialised sandbinder and will not hold sand or form a dune structure in the same way as spinifex and pingao.

Gardening in the sand dunes around residential areas is reasonably common in the Bay of Plenty, and it is most likely that South African iceplant arrived in the dunes from adjacent gardens, dumping of green waste, and active gardening. Education and getting buy-in from local residents will be critical, as many people prefer a gardened dune to a natural New Zealand dune ecosystem.

Saltwater paspalum

Although near its southern distribution limit in the Bay of Plenty (Shaw and Allen, 2003), saltwater paspalum is widespread across the Bay of Plenty Region. The identification of this species on only ten transects underestimates its distribution in the region, although it is likely to be more prevalent in estuaries and river mouths than on sand dunes. It is present at several sites including Tauranga Harbour, Ohiwa Harbour and Waiotahe Estuary.

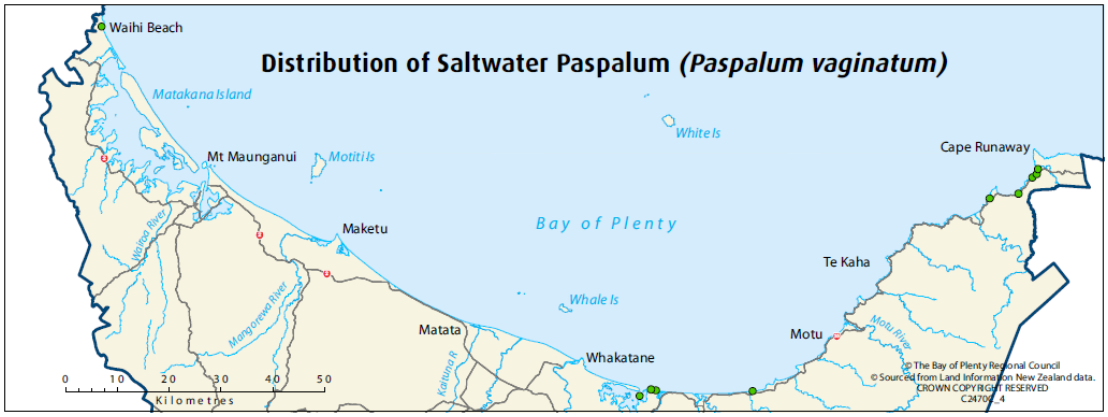


Figure 18 Distribution of Saltwater Paspalum.

Saltwater paspalum will establish in a variety of coastal vegetation, including dunes with spinifex and pingao. It forms dense swards and spreads readily by fragments and growth of stolons (Shaw and Allen, 2003). It changes the composition and structure of existing vegetation, with the potential to overtop low statured species (Shaw and Allen, 2003). It is unlikely to outcompete other plants outside the saline environment, which may limit its spread into dunes, although it remains a threat to the ecology of estuarine habitats.

Buffalo grass

This species doesn't appear on any of the transects and only shows up in one vegetation type that covers a quarter of a hectare. It was recorded at low densities (5% or less) on five of the sites scattered across the region (Central Waihi Beach, Matakana Island 1, Shark Alley to Kaituna Spit, Pāpāmoa, Pukehina Beach, West End dunes, and Hikuwai Beach.

Buffalo grass is tolerant of the coastal environment and will smother native plants and seedlings (Weed busters website, 2010). It does have the potential to become a much bigger problem if allowed to take off, with potential to dominate the vegetation and prevent indigenous regeneration. It is only limited by heavy frost and moderate shade, neither of which is especially common on the Bay of Plenty dunes. Because it is currently at low densities a watching brief may be an option, although in many cases by the time the threat of a pest plant has been recognised it has become a major and widespread problem. It may be preferable to control it wherever it occurs in an attempt to prevent it from spreading exponentially.

Pig's ear

This plant was not identified on any of the transects or in any of the vegetation types. It was noted as present at very low densities (<1%) along the coast from Pāpāmoa to the eastern end of Pukehina. Because it is fairly prominent and relatively easy to locate, a species led approach might be appropriate. Again, buy in and education from local residents will be important to avoid this plant re-establishing from dumped garden waste or being deliberately planted, however it is one species that would be reasonably simple to remove from the dunes.

Evergreen buckthorn

Evergreen buckthorn has a slightly more extensive but similar distribution to pig's ear, occurring on Matakana Island and then on the coast from Mount Maunganui to the eastern end of Maketū Spit in low densities (<1%). Some buckthorn control has been undertaken in those dune areas by Tauranga City Council and Bay of Plenty Regional Council, and a species led approach for this species on that stretch of coast is likely to be a feasible management option. Buckthorn is prominent and it is reasonably easy to find and kill the adult plants, but it produces abundant, long-lived seeds that are dispersed by birds and could reappear nearly anywhere. Only a few thousand plants have been found on the stretch of coast already controlled, which is a positive sign, but will require follow-up for quite some time before it can be assumed to be eradicated.

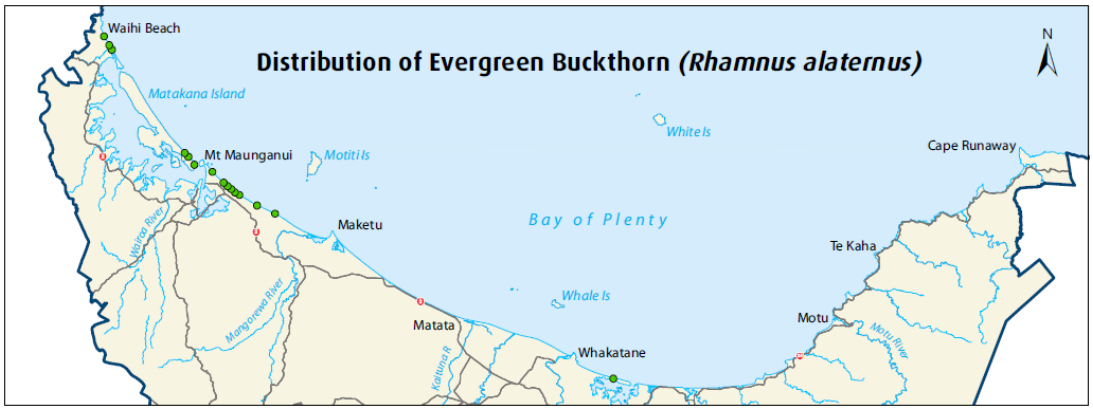


Figure 19 Distribution of Evergreen Buckthorn.

African boxthorn

This species occurs on 32% of transects (52), and is more commonly found in the eastern Bay of Plenty than the western. It was found on the vast majority of transects between Ōtamarākau and Whakatāne. It was also found at Ōhope Spit and on the transects from Ōpōtiki east to Omarumutu. In the western areas it was found at Pukehina, on Maketū Spit, Waihī and Orokawa Bay, but less frequently than in the rest of the region. African boxthorn is an aggressive coloniser of dunes and tolerates wide range of conditions including salt spray (Weedbusters website, 2010). It displaces other species, particularly woody shrubs. It is reasonably easily controlled, using the best methods, but quite widespread and its management would require a reasonably long term programme.

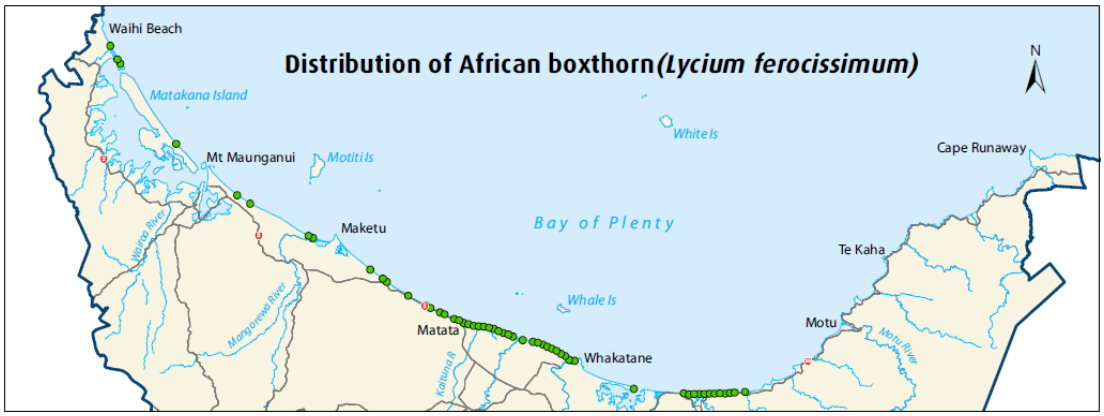


Figure 20 Distribution of African boxthorn.

Japanese spindle tree

Japanese spindle tree was noted on 13 transects at Pāpāmoa, Thornton and Ōhope, at no more than 5% cover. It was not a component of any of the vegetation mapping, therefore not a major component of the vegetation along the dunes. This species forms dense stands, can out-compete native species and threatens coastal forest and scrub as well as the dunes. Species led management might be an option for Japanese spindle tree, but education and local buy-in would also be important as it is commonly used in variegated form in coastal gardens. A 'plant me instead' approach to local gardeners may also be a tool, as the native taupata and coastal mahoe looks similar, although not variegated.

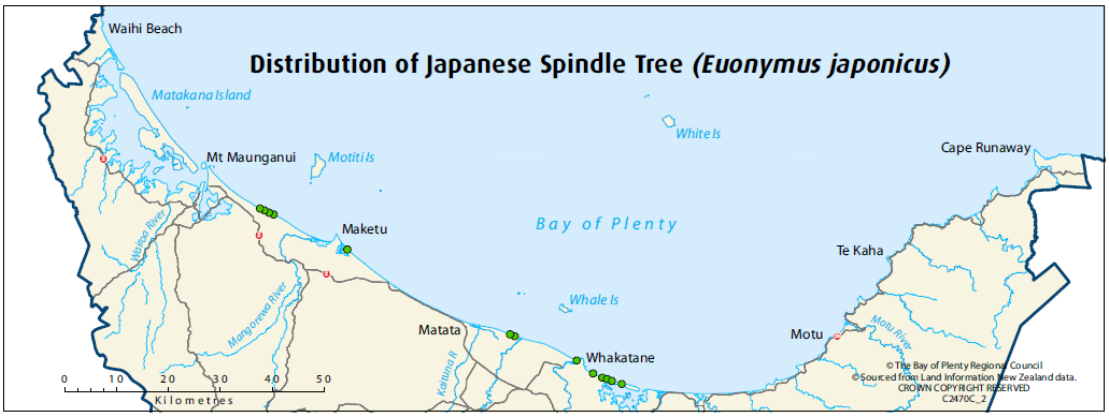


Figure 21 Distribution of Japanese Spindle Tree.

7.8 Factors impacting on dune vegetation

There is a long list of factors that impact on dune vegetation, however they can be summarised as impacts relating to:

- Human foot and vehicular traffic – mostly in the form of tracking which leaves areas of bare sand.
- Pest animals – mostly rabbits, but also domestic stock and use of the dunes for grazing.
- Pest plants – this includes exotic garden escapes and ecologically incorrect aesthetic plantings which may involve either garden plants or inappropriate native species and damage from the control of pest plants.
- Dumping of litter, organic and in-organic waste.
- Erosion and blowouts.
- Structures.
- Restoration planting.
- Clearance.

The complete list of impacts scored is in Appendix 10.

Positive impacts included restoration planting, some indigenous plantings and official walking tracks. Formed walkways are considered positive in most cases because they reduce the amount of informal tracking through the dunes. The rest of the impacts noted were all negative.

Figure 22 below shows the average number of positive and negative impacts per transect[20], which ranged from zero to nine. Over half (56.6%) of the transects had between 2 and 4 impacts occurring within them. The vast majority of transects had at least two impacts present, and 36% had five or more impacts. The average number of impacts per transect was four.

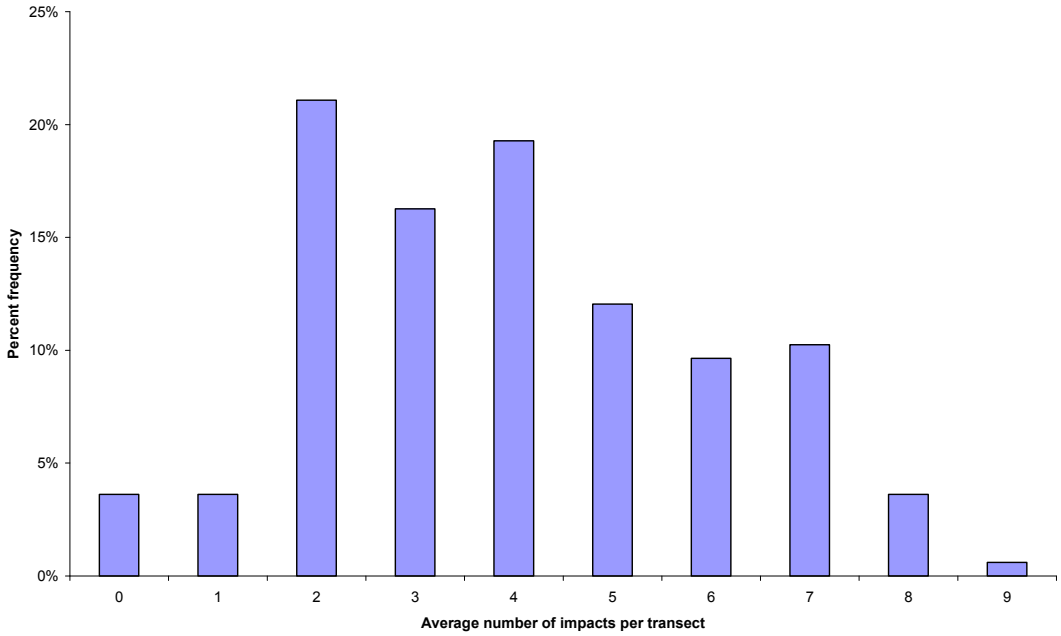


Figure 22 Percent frequency of impacts per transect.

Anything that impacts negatively on the dunes is a concern, however the fact that most of our dunes are subject to multiple negative impacts at the same time is even more troubling. Combinations of impacts serve only to exacerbate the problems caused by any one of the issues. For example, a combination of a pest plant and damage to vegetation cover, or dumping of organic waste can accelerate the spread of pest plants by providing organic matter and sometimes propagules that provide for their establishment and opening space. The addition of stock to an already damaged dune system can worsen existing erosion problems and recovery of dune vegetation is altered by changes to the nutrient status of sandy soil and 'new' exotic plant species transported into the site by the animals.

Associations of cause and effect are well beyond the scope of this monitoring, however it can be said that some impacts can worsen the effects of others, and some impacts can be directly attributed, in some cases, to another. For example there is an association between organic waste dumping, or exotic gardening and pest plant invasion. This is evident in front of residential areas across the region, where a garden plant has established and moved further into the dunes. South African iceplant and some succulents have invaded the dunes by these means. Vehicles create good conditions for blowouts where they drive down from the top of the fore dune to the beach by removing vegetation and lowering a portion of the dune. This creates a wind tunnel effect and sand is rapidly moved inland from the top of the first dune.

[20] Number of impacts is gathered for each polygon on a transect, therefore an average per transect was calculated.

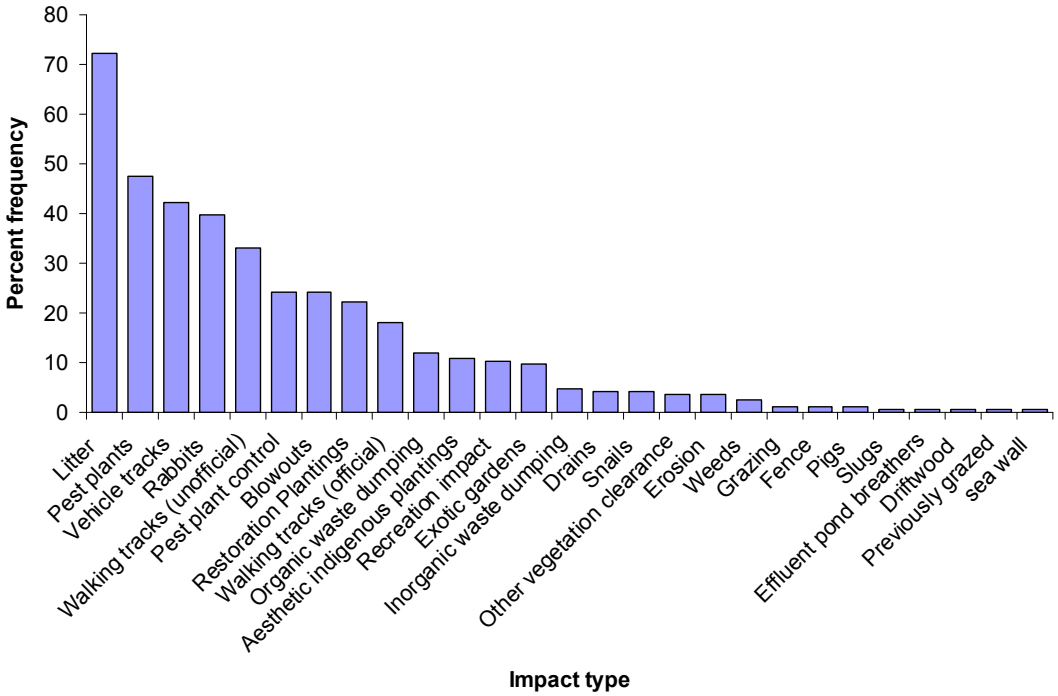


Figure 23 Percent frequency of impact type by transect.

The most common impact was litter, which occurred on 73% of all transects at low levels right across the region. Although at low levels, and not a significant ecological issue, litter is still a negative impact and extremely hard to control. In terms of biodiversity, litter that is scattered small items of food packaging, for example, is not ecologically damaging and can often be discounted as a concern for anything except public health and unsightliness. It may occasionally injure wildlife, but does not impact greatly on vegetation unless it is part of a large area of inorganic dumping.

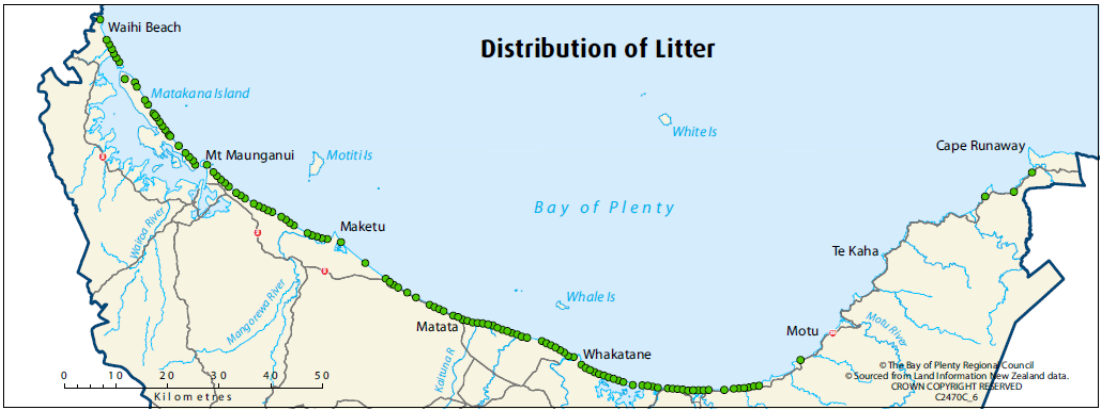


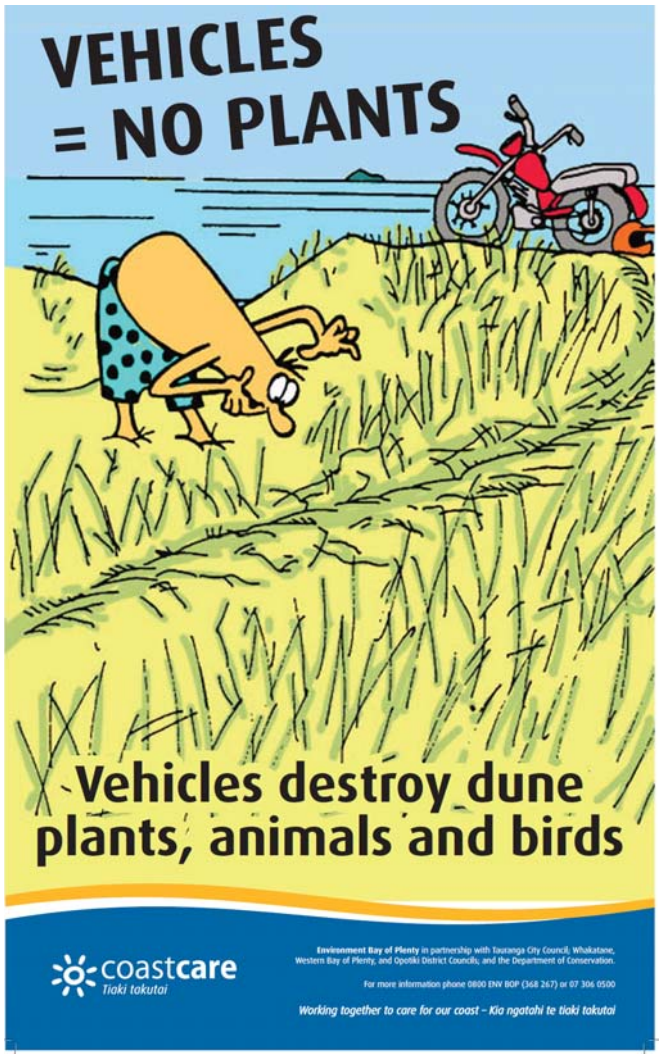
Figure 24 Distribution of litter.

Other negative impacts that occurred frequently on the transects are pest plants (48%) and vehicle tracks (42%), rabbits (40%) and unofficial walking tracks (33%).

Pest plants were recorded as an impact on nearly all the transects west of Ōtamarākau, but only on three transects to the east of Ōtamarākau. In looking at pest plant cover, eight transects located east of Ōtamarākau had more than 50% pest plant cover and it seems contradictory that these transects were not all recorded as being negatively impacted by pest plants. In fact, none of those transects were recorded as being impacted on by pest plants at all.

The field staff for the western half of the region (i.e. west of Otamarakau) developed the methodology, and for that part of the region all but one transect has pest plants scored as a negative impact. About half of those transects scored the impact as having a moderate to major negative effect. The field team for the eastern part of the region interpreted the methodology differently, and did not record widespread naturalised exotic grasses (e.g. harestail) as a negative impact. They scored pest plants in the impacts section where those pest plants were particularly invasive and damaging, such as marram and pampas (Heather MacKenzie, 2010 pers. comm.). From an ecological perspective the distinction may or may not be valid. As already mentioned, there are exotic species that do not have major impacts by changing processes, dune structures, or dominating vegetation, but without having a list of precisely what species were not considered a negative pest plant impact, it can not be determined either way. The issue from an ecological perspective is that while widespread grasses may not have a prominence or dramatic impact, they still quietly occupy the dunes both excluding native species, and changing the conditions that many of our dune land species need to exist. Pasture grasses still change the vegetation associations.

Vehicle tracks appeared more frequently in the region east of Ōtamarākau, with most transects between Ōtamarākau and Whakatāne affected. Transects from the Waioeka River east were also affected, particularly around Ōpōtiki township and the Waiaua River mouth at popular access points. There seemed to be a negative association with dense residential housing in the western Bay of Plenty and Ohope, presumably because there is either little requirement for people to access the beach using a vehicle except at identified boat launching sites, or houses front directly onto the dunes, thus restricting vehicle access. Vehicles tend to be used in the more isolated parts of the dunes probably because formal access ways are few. Fishers drive along the dunes to access fishing sites, rather than using established access points and then driving along the beach. Interestingly only a few



transects were considered to have more than minor effects on average, despite the multiple damaging effects vehicles have on dunes (vegetation damage, increase blowouts, facilitate weed invasion, amongst others). Even in the individual polygons on the transects, most vehicle impacts were recorded as minor. This may be because in many instances vehicles tend to stay confined to a single vehicle width along the dune crest. From a biodiversity perspective, however, a vehicle track is essentially a desert where no vegetation is able to exist.

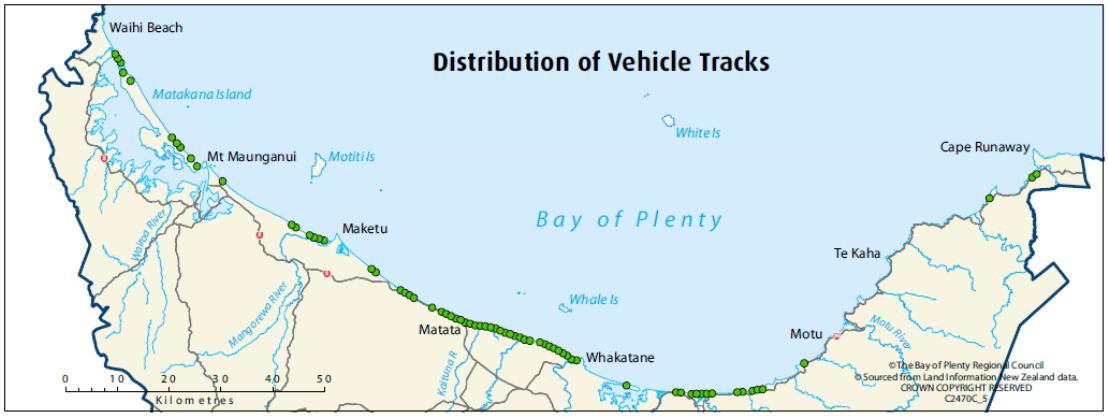


Figure 25 Distribution of vehicle tracks.

There was no pattern in the distribution of transects that had rabbit impacts. They were spread right across the region, with the vast majority being considered to have minor negative effects from rabbits. Rabbits damage dunes by feeding preferentially on species like pingao and *Euphorbia*, and damage other species like spinifex and pohuehue. Browsing on spinifex and pingao limits runner growth, which affects incipient foredune development and dune repair. Rabbits also reduce seedling establishment. All of this results in selective removal of some species from the vegetation matrix. Digging can contribute to erosion and plant damage, and faecal pellets can alter the soil nutrient status.

igure 26

Distribution of vehicle tracks.

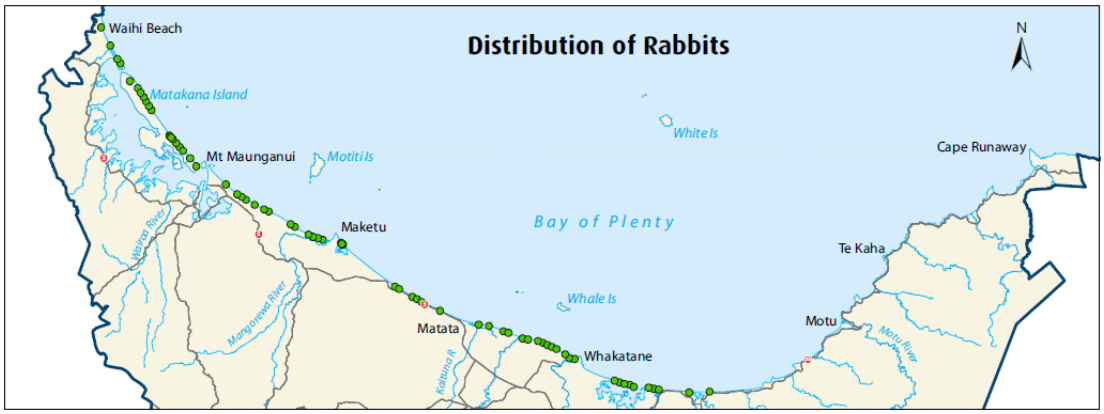


Figure 27 Distribution of rabbits.

Unofficial walking tracks were scattered across the region, tending to occur more often in association with housing areas along the Bay of Plenty Coast than in the more remote stretches along the Matatā Straights and other areas where housing is largely absent. This result is not unexpected, but is still disappointing given the number of official access points to most of the populated beaches. Every residential property appears to have its own single access track, especially where houses front directly onto the dunes. Most people would not consider detouring 20 m to left or right to use a formal or shared access, and it is unlikely that this attitude will change. Developers often talk about having shared access ways for adjacent land parcels, but in reality individual households rarely share a common walkway.

Some activities that were not recorded as frequently are still of considerable concern. Exotic gardens are the first step to exotic plant infestations in the dunes, and often involve species that create more organic matter and alter the soils so that they no longer favour indigenous sand dune species. Different species also produce different dune profiles which can exacerbate erosion issues where dune toes are close to houses as they are at Pukehina. Sometimes those creating the gardens also add soils to make the gardens feasible. Exotic gardens were noted on 16 transects (9.6%), and with the exception of a marijuana plantation at Thornton, all were associated with housing. One was a clear encroachment into public reserve.

Figure 28 Exotic gardens are a major source of weed invasion in dunes.

Waste dumping, organic or inorganic is unsightly. It can include contaminants, and a lot of organic waste contains plant propagules from sites where people are trying to remove them, resulting in 'garden escapes' establishing in the dunes. Organic waste composts and shifts the soils from the more sterile sandy soil to a substrate with more organic matter, which opens it to invasion by exotic species that can not tolerate a pure sand base. Not to mention the supply of propagules within the garden waste. Waste dumping was strongly associated with housing. East of Opotiki where housing is more sparse, transects that recorded some waste dumping were near houses or groups of houses. West of Opotiki it was always associated with housing, with the exception of one transect at Kaituna on the Te Tumu lands where the inorganic waste has been noted by the landowners and measures taken to prevent further dumping. Where organic waste was described it was always garden waste and/or lawn clippings. Having seen first hand the blatant dumping of garden waste and lawn clippings at Ohope, this result comes as no surprise. It is, however, an ongoing issue that requires education and an attitude shift from those living adjacent to dunes that seem to view them as wastelands, or areas they wish to populate with what they see as more visually appealing vegetation.

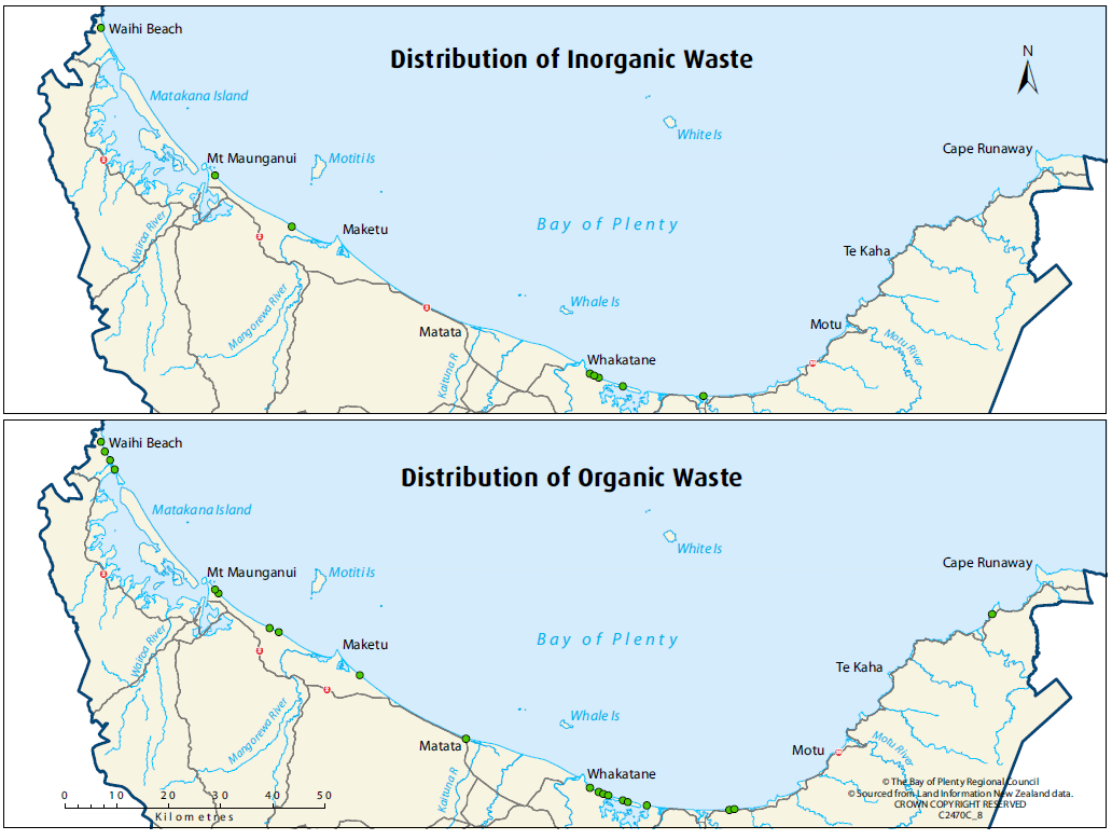


Figure 29 Distribution of inorganic and organic waste.

Vegetation clearance was relatively rare, and was recorded on 3.6% of transects, however it is often irreversible, depending on the purpose for which the vegetation has been cleared. Where pasture is created, the dunes are unlikely to be allowed to revert, despite being marginal for this purpose. Encroachments can also start with clearing dune vegetation before establishing lawns or gardens and is difficult to reverse, although some gains are being made along Papamoa by Tauranga City Council.

Figure 30 A section of Pāpāmoa Beach showing clear encroachments and informal tracking from most houses.

Pest plant control was noted as a positive impact except for one site where some collateral damage must have occurred. The twenty transects (24%) with pest plant control were fairly widespread across the region and included half the transects on the stretch of coast between Ōtamarākau and the Tarawera River, and a stretch of Matakana Island where coastal tea tree control is being done. Most pest plant control was occurring along the residential housing frontage.

Restoration plantings followed very similar patterns, however both activities occurred together on only 16 of the transects, suggesting that the two activities are not necessarily related. Where both activities occur on the same transect it is possible that they are part of a Coast Care project, but this can not be verified as Coast Care has not mapped specific work areas to date. Coast Care works to date have largely concentrated on the fore dune focussing on re-establishing native sand binders for biodiversity benefits and infrastructure protection in bare areas, especially around vehicle and foot traffic areas.

Part 8: Operational work programmes on dunes

8.1 Coast Care

Coast Care Bay of Plenty was formally initiated in 1994 as a response to the ongoing degradation of natural dune systems (de Monchy, 2009a). It is a partnership between communities and local government and aims[21]:

1 To educate those who manage, benefit from or use Bay of Plenty beaches about natural dune ecosystems.

2 To increase community involvement in the management of Bay of Plenty beaches.

3 To protect and enhance the natural character and biodiversity of Bay of Plenty beaches.

4 To improve the capacity of dune systems to withstand coastal hazards and relevant climate change effects.

The programme is jointly funded by the partner agencies: Department of Conservation, Western Bay of Plenty District Council, Tauranga City Council, Whakatāne District Council, Ōpōtiki District Council, Bay of Plenty Regional Council (Jenks and O'Neill, 2004). A full time role is funded by the partner agencies to coordinate the programme.

igure 31 Re-contoured dune face, Ōhope Beach, 5 October 2009.

On the ground operations involve planting native dune species, managing dune access, controlling pest plants and pest animals. About 43% of the 156 km sandy coastline has been worked on by Coast Care staff and volunteers since 1994 (de Monchy, 2009a). While most operations follow well tested methods, some experimental work is also undertaken, such as re-contouring a steep scarp at Ōhope Beach and planting sand binding plants to re-establish a gently sloping dune face. Figure 29 shows the un-contoured scarp face on the left of the frame in contrast with the newly contoured and planted area to the right of the frame. The profile has been altered by weather events in 2010. Rabbit control is an important part of the programme to prevent damage to new plantings and established vegetation.

[21] Goals of Coast Care BOP from de Monchy (2009a).

The Long Term Plan for Partner Agencies was developed in 2009 (de Monchy, 2009a) with involvement from all the partner agencies. It reinforces the original intent of Coast Care while also aiming to extend some aspects of the programme. Objectives relevant to improving biodiversity values in the dune lands include:

Objective 3.1: Write and implement annual site management plans for each sandy beach taking into account the objectives and information sources above and identifying key threats and opportunities to prioritise Coast Care actions at each site and across the Bay of Plenty region[22].

Objective 3.2: Increase the length of sandy coast (excluding any seawall or hard structure areas) under "advanced"[23] or "active"[24] Coast Care management from 43% to at least 53% as specified in the draft Environment Bay of Plenty 10 year plan.

Objective 3.3: Increase the length of sandy coast where spinifex is established from 64% to 74%.

Objective 3.4: Increase the distribution and abundance of threatened dune plant species, and back dune plant communities, by including these in site plans where appropriate.

A monitoring component is also included. The sandy coastline has been divided into activity areas for works. Specific planting areas have not been comprehensively mapped to date. This has meant that vegetation types that are largely due to Coast Care management can not be correlated to known restoration sites with any certainty.

An assessment of rabbit densities is completed annually using a modified McLean Scale applied to 200 m sections of the coastline. Control is often (but not always) undertaken where the modified McLean Scale is >2, although there are some issues with control east of the Waioeka River due to the lack of an effective control technique that is safe for weka.

The rapid coastal inventory completed in 2009 showed that spinifex is present on 64.1% of the sandy coastline, pingao on 12.7% of the coastline, and that vegetation cover was highly variable. There is still a considerable proportion of the coastline that may benefit from dune restoration and 17.68 km were identified that could be re-planted immediately with no need for mechanical intervention (de Monchy, 2009b). The rapid coastal inventory will be repeated biennially (due late 2010) as a way of measuring and reporting on Coast Care activities and processes affecting them. The different methodology was applied specifically for Coast Care purposes and does not translate to regional dune condition and extent monitoring.

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[22] Coast Care site plans shall take into account the following factors, in order of priority, when deciding how much to resource each site:
a) Feasibility of achieving a successful outcome, including consideration of cost/benefit ratio.
b) Absence of indigenous fore dune vegetation.
c) Level of community interest in protecting the dunes.
d) Ecological significance of the site (for example, Significant Natural Area or 'corridor').
e) Risk to any infrastructure or community assets from coastal hazards.

[23] **Advanced management** by Coast Care is defined as areas where: a) planting native fore dune species was completed at least three years prior to date of assessment, and b) growth rates are sufficiently rapid to ensure the plants are naturally colonising any bare sand, and c) where established plants have restored an incipient fore dune, and d) the dune is now more resilient to wave attack, and e) the dune is now sufficiently wide to self-repair following normal erosion episodes, and f) back dune planting has often commenced.

[24] **Active Management** by Coast Care is defined as areas where: a) fore dune planting has commenced but not yet been completed, and b) criteria b), c), d) e) and f) in Note 1 are yet to be achieved. All areas not covered by footnote 22 or 23 are considered to have **Nil management**.

Although it does have the potential to add to the information base its focus is on operational needs and results.

The Coast Care programme has considerable potential to deliver good ecological outcomes for dunes. The focus for works is still largely on the fore dunes and driven by the desire of communities to reduce erosion. But the objective to include rear dune plant communities for consideration indicates an expansion of the philosophy to include the full extent of dunes over time. Resources may still be a limiting factor in how far inland work might extend, but there will be opportunities to coordinate with Coast Care activities through the Biodiversity Programme (discussed below) and achieve more comprehensive management of the dune system. Coast Care is currently our best and most public vehicle for education about the values of dune lands, and the value of this in changing attitudes and treatment of the dunes should not be underestimated.

8.2 Bay of Plenty Regional Council Biodiversity Programme[25]

The Biodiversity Programme was initiated in June 2009 as part of the Ten Year Plan. It contributes directly to our obligations under the RMA to maintain indigenous biodiversity, and the community outcome of "A clean and protected environment". The Biodiversity Programme supports the protection of indigenous biodiversity by landowners and the community with a focus on sites of highest ecological and/or community value. Levels of service in the Ten Year Plan 2009-2019 are:

Table 7 Ten Year Plan levels of service and key performance indicators 2009-2019.

Levels of service	Links to community outcomes	Key performance indicators	Target				
			Current	Year 1 2009/10	Year 2 2010/12	Year 3 2011/12	Years 4 to Year 10 2012/13 to 2018/19
Council works with landowners and community groups to improve the region's biodiversity at significant sites.	A clean and protected environment. Respected culture and heritage. A prosperous and sustainable economy. Open and inclusive leadership.	Percentage of High Value Ecological Sites on private land that is under active management.	26%	30%	33%	35%	Steadily increasing to 50% by Year 10.
		Number of landowner and community high value biodiversity sites supported by Council.	61 sites	64 sites	67 sites	70 sites	Steadily increasing to 91 sites by Year 10.

High value ecological sites (HVES) were identified using information available at the time, assessed on a range of ecological criteria and essentially filtered out of a larger list of biodiversity sites for the region. They are on private land or have a private land component. Landowner and community biodiversity sites are those sites with biodiversity values present which landowners and the community wish to protect, but which are not HVES. The HVES are a higher priority for protection and are also the sites where the greatest biodiversity benefits are likely to be gained.

HVES cover 47.8% (1013 ha) of the mapped dune vegetation. Matakana Island's seaward dunes account for 500 ha of this. Areas of dune vegetation not covered by HVES are largely administered by the Department of Conservation or the District Councils.

[25] This section largely adapted from Environment Bay of Plenty (2009).

This programme relies on the willingness of landowners to manage sites on their property. Although the HVES are the higher biodiversity priority, landowner willingness is generally the key to achieving management of a site and provided budget it available sites of lesser quality can also be managed. The Biodiversity Programme caters for sites of varying ecological value by using different grant rates for different sites. HVES can be funded at up to a 75% subsidy from the Bay of Plenty Regional Council, while non-HVES can be funded up to 50%. Funds go towards operational works such as fencing (except boundary fencing), pest plant and pest animal control, management of other threats to a site, and outcome monitoring.

Landowners enter into an agreement with the Regional Council through a Biodiversity Management Plan (BMP) which includes a programme of works for up to five years. The BMP is reviewed at the end of its time and a new BMP may be developed for the next stage of management if necessary. Management on public lands administered by the Department of Conservation and District Councils can occur, but those areas are only eligible where a Care Group is established to undertake the work. Hands on intervention with threatened fauna is not considered the role of the Regional Council, but complementary works to maintain and enhance habitat are within the scope of this programme.

Although the HVES and other biodiversity areas are identified as discrete sites, the BMP does not need to cover the entire site, although management of the whole site is the ultimate goal. The advantage of this in the sand dunes context is that it means that sections of sand dunes can be managed regardless of being delineated as a discrete site or not. This caters for complementing Coast Care projects on the front of the fore dune, by enabling work to be undertaken in the rear fore dunes thereby achieving full coverage of the dune extent. It also enables a strategic approach of controlling pest plants and animals to a high level in one section before moving to the next, avoiding spreading resources too thinly.

The Biodiversity Programme is more flexible than Coast Care and has a scope that targets maintenance of biodiversity values as its primary goal, rather than being (at least initially) driven by the community's desire to prevent dune erosion. BMPs can cater for management activities that benefit fauna, and has potential to target particular flora to enhance threatened species populations. The Biodiversity Programme may be more appropriate as a vehicle for achieving management of the dunes from toe to inland extent for biodiversity purposes, but doesn't preclude the continuation of Coast Care's wider role (in the sense of including education and coastal hazard management) in dune protection. Both programmes allow for incremental gains in coverage because they are not tied to any site or other boundaries.

At this stage there is one BMP in negotiation that is located on dune land vegetation. There are also two BMPs in process for Thornton kanuka, but only a very small section of these is located on the mapped dune vegetation extent, incorporating remnant kanuka on grazed land.

8.3 Matata Straights project

This project is still in development and is at the scoping report stage. A joint project charter has been agreed on by the Bay of Plenty Regional Council and Whakatāne District council to develop a sustainable management strategy for the coastal area between Otamarakau and Matata. The 'coastal area' would include the dunes as an integral part of the project and as such this project will provide considerable biodiversity benefits to the dunes (Simon Stokes, 2010, pers. comm).

8.4 Department of Conservation

The Department of Conservation does not administer extensive areas of dunes but they do some operational work in areas they do administer at Matata, Ōhope Spit, Thornton Lagoon Wildlife Management Reserve, Tirohanga and Waiotahi. They have ongoing programmes for pest plant control at each of those sites. Works are reviewed annually and a plan made for the coming season of works. The operations have targeted pest plants in decreasing order of priority, bringing the high priority pest plants under control, and ensuring they are controlled wherever they reappear before moving onto the next priority. Species included in control span the range of dune land pest plants such as pampas, boxthorn, and gorse.

At Thornton a revegetation programme is underway, using Thornton kanuka to boost the population size and distribution.

The Department of Conservation also coordinate with Coast Care for some sites.

8.5 Ōpōtiki District Council

Ōpōtiki District Council mostly focus on areas around Island View and Waiotahi Drifts subdivisions, using development contributions. Funds are used for forming and maintaining formal access points to the beach, as well as operations like pest plant control and planting on front and rear fore dunes. Work is also being done at Hikuwai Beach. The bulk of the works are about managing access through the dunes to the beach.

A cycle way is being planned for part of the dunes which could have implications for those sections.

(This section Mike Houghton 2010, pers. comm).

8.6 Whakatāne District Council

Much of the work done in the Whakatāne District dunes is in conjunction with Coast Care. Volunteers from Coast Care do some pest plant control work, such as ice plant removal, but this is often dictated by local area of interest for those volunteers.

Reserves management plans are now aging but still relevant, and do provide some guidance.

Whakatāne District Council has planted some Thornton kanuka in back dunes around Walker Road, which is the main area for this species. There appears to be some conflict between representing for the protection of Thornton kanuka while administering grazing leases on lands with some remnant kanuka remaining. As these leases expire, the council is changing them to an annual review term which makes it easier to progressively retire these blocks rather than having to wait for a five or ten year lease to expire.

Whakatāne District Council has controlled some pest plant species along the stretch between Ōtamarākau and Matatā in an ongoing programme which has seen visible positive results.

Whakatāne's main revegetation project aims to plant areas of rear foredunes that have gaps left by pampas control. An ongoing pampas programme was begun several years ago from Matata to Otamarakau and the revegetation is working in those areas, filling gaps at a rate of about 1 ha per year. Essentially the project aims to manage vegetation cover to reduce pampas re-invasion.

Some work is done in association with lease holders, targeting boxthorn, however some care has to be taken as coastal mahoe grows in the shelter of boxthorn in some places. Work on Ōhope Spit on the areas transferred from the Department of Conservation to the District Council is being maintained, however resources are not available to expand beyond that.

Restricting vehicle access to dunes is still a challenge especially along Matata Straights. Investigation into a coastal cycle way is continuing. Investment in the cycle way infrastructure would give more weight to excluding vehicles, although as with Ōpōtiki District, it will have implications for existing dune vegetation depending on where it is located.

(This section Pete McLaren, 2010 pers. Comm).

8.7 Western Bay of Plenty District Council

Western Bay of Plenty District Council achieves dune management activities through coordination with Coast Care. Little work is undertaken outside of the Coast Care activities, although some gorse and pampas control may be done on the dunes at Bowentown.

(This section Peter Watson, 2010 pers. comm).

8.8 Tauranga City Council

The Coastal Reserves Management Plan (Tauranga District Council, 1997) provides general direction that guides operational works in the dunes. For example it lists pest plant removal where practicable, and the use of eco-sourced indigenous plants for the dunes. There is a Coastal Ranger to coordinate the dunes work.

At this time the one focus is dealing with encroachments issues from residents into the dunes.

Such encroachments, both structural (e.g. fences, benches) and non-structural (e.g. lawn grass and gardens) are removed, and the site is prepared for planting. Tauranga City Council then coordinates with Coast Care volunteers to undertake the planting, and follow-up maintenance is done by a weed control contractor and Periodic Detention (PD) crews.

Renewal and maintenance of sand ladders and fences is ongoing, but does benefit biodiversity by excluding damaging activities and reducing informal tracking.

Some species led work is done, and some site led. There is a list of weeds in order of priority for control. Buckthorn has been dealt with as the first priority and the programme is now moving on to agapanthus. Coast Care volunteers help by pulling iceplant, and the Coastal Ranger provides some direction for areas where this is needed. Guidance and prompting is also sought from Regional Council staff as to what works are needed where.

The area around Karewa Parade has been managed as a site and weeds have been removed to leave about one kilometre of the dunes more or less weed free. The plan is to continue moving west with this approach.

Weed control at all sites is followed up with planting as necessary.

(This section Stephanie Brackstone, 2010 pers. comm).

Part 9: Discussion

9.1 Methodology

Vegetation mapping has inherent errors that cannot be avoided. There is currently no standard methodology for monitoring dune lands in New Zealand. This method is designed to identify reasonably large changes over reasonably long time scales of five to 10 years. As with the recce method (Hurst and Allen, 2007), it is intended to use the data to monitor structural and compositional changes in vegetation over time.

There is a large volume of data and it is a little awkward to work with. Data layout in the spreadsheets needs some review and clear descriptions of layouts also need to be written for future application as different people will be applying the method over time. It also requires a lot of data entry associated with the GIS spatial layers to get maximum benefit. While this is not a major issue in itself, translation of the data from field sheet to spreadsheet and/or GIS layers can introduce errors to the data which may not be noticed during analysis.

Identifying change will rely on being able to calculate the areas of each polygon and its vegetation type, and associated exotic species cover with each vegetation polygon. The main condition measures are considered to be the dominance of exotic or indigenous species in each polygon and/or transect and the level of impacts associated with each polygon and/or transect. The statistical robustness of the data will not really be tested until the next re-measure is completed, and not all of the data will be able to be subjected to statistical testing.

One of the biggest gaps in the data is the lack of a more quantitative and less subjective element. Error is increased in a data set where different people are making subjective cover estimates using uneven categories of cover. This is generally overcome by gathering a lot of data and looking at long term trends, rather than placing emphasis on short term fluctuations. Having one or more of the same team members at each measure can also help.

The Department of Conservation has developed a monitoring toolbox to guide staff in applying the most appropriate method for the target habitat type and purpose (McNutt *et al*, 2007). Using this for guidance, the method that seems most applicable for sand dunes would be the Scott Height Frequency (SHF) method. SHF produces statistically testable data and can be used to identify changes in stature and species composition and structure, particularly where a management or pest impact is occurring (Rose, 2009). This method would reduce some of the variation caused by the use of different field teams applying a subjective method from year to year. The accepted standard is to include a recce plot (as per Hurst and Allen, 2007) along the SHF transects and recce data, although it uses subjective estimates, is also statistically testable (Hurst and Allen, 2007). A very small scale trial was undertaken with a Bay of Plenty Polytechnic student, however the results have yet to be examined. Based on this trial, the work would take 84 days at two transects per day, and would involve considerable cost and time commitments.

The use of two different field teams for data collection is a major weakness of the project and highlights the need firstly for a more objective quantitative component, and secondly for clear methodology descriptions and explanations. It also means that some parts of the data must be viewed with caution as scoring appears to have been applied differently in the two halves of the region. The second field team spent time with the Wildland Consultants field staff learning the method, but it appears that some elements evolved over time so that the methodology applied at that time had

evolved by the time the first half of the region was completed. The report produced by Wildland Consultants (2008) as the methodology description seemed adequate until it was applied in the field. At that point a number of factors were open to interpretation. This also means that future re-measures may apply scoring slightly differently again so that results showing change may be as much a reflection of the application of the method as it is of real change. This is true of most subjective methods, but some work to improve the consistency of data collection would be worthwhile, and the addition of a quantitative element can also reduce observer variation.

One of the issues that arose was a lack of consistency in scoring indigenous or exotic species cover across each site and each transect and the exotic species cover was scored differently by the two field teams. This has been briefly discussed in section 7.7. Both these issues could be resolved by improving the field manual to ensure that field staff apply the scoring in the same way from year to year and a checklist would help ensure that all tasks are completed at all sites.

The data collected uses a nested design. This was done so that the entire dune system could be re-mapped at a lesser frequency than the transects to reduce the high costs of that type of work. The transects were designed as a sampling system that would be re-measured at three to five yearly intervals and provide a higher level of detail than the general mapping. The site mapping was envisaged to be repeated every ten years. This would have to coincide with the most recent aerial photography available at the time to ensure good accuracy of mapping. The issue is not the use of transects at a higher frequency, but rather that the nested data can be confusing and it is debatable as to how much greater detail has been determined from the transect mapping. But using the transects allows a sample to be taken from the dunes more frequently than a complete mapping exercise.

What we have achieved through this work is complete ground-truthed coverage of the region's dune vegetation which provides a good overall baseline for future monitoring of dune extent. The mapping was also tied to delineated sites which allows correlation with sites identified in background reports for coastal planning and for the biodiversity programme.

This mapping can contribute directly to national monitoring of the National Priorities (Ministry for the Environment and Department of Conservation, 2007). In addition, the placement of transects across the region provides a good sampling basis for the application of other ecological survey and/or monitoring work relating to the dunes. The Scott Height Frequency methodology could be appropriately applied at the existing transects, and any possible fauna monitoring could also be located at the transects.

9.2 Fauna monitoring

Knowledge of fauna distribution and abundance in the dunes is fairly sparse, with the exception of shorebirds. This is a gap in terms of monitoring whether or not we are maintaining biodiversity in the dunes, as this project set out to map the extent and condition of the vegetation only. It could be argued that wildlife is not the responsibility of regional councils, however if it is not considered appropriate to undertake the work, the Regional Council is still in a position to facilitate and encourage work that supplements this project. Ignoring the fauna component of biodiversity will not give us a full picture of what we might be achieving in the dunes through habitat maintenance and restoration. Providing good habitat does not equate to increasing fauna populations as immigration back to restored habitat may be impeded and this can not be determined where there is no monitoring of fauna species.

Fauna can be problematic and expensive to survey, which is why they are so often left out of ecological survey and monitoring. There are a number of options that could be investigated for fauna monitoring. The vegetation transects could be used as a basis for sampling fauna using appropriate methods (e.g. Jamieson, 2010; Patrick, 2002), which would tie in well with the vegetation monitoring and any additional quantitative component that may be added. Because this is a grey area for Regional Councils some thought would need to be given as to how to achieve it in the most appropriate way.

9.3 Regional and district plan provisions for dune land ecosystems

While all the regional and district plans recognise that there are issues in terms of degradation of the natural character of the dunes, the protection provided by those plans is variable. On face value, the dunes should be adequately protected by the combination of regional and district plans, but in reality there appears to be a lack of enforcement of some of the provisions. This is particularly true of district council bylaws. Most district councils have difficulties with personnel capacity to patrol beaches and dunes to enforce their bylaws. This is evidenced by the prevalence of vehicle tracks on large areas of dunes in the region, amongst other negative impacts that are the result of human use and abuse of dune areas.

Also of concern is that development, infrastructure and property protection are constantly being given higher priority than the maintenance of an ecosystem that simply has no other place to exist. The reality of the extent of existing residential housing, roading and public facilities on and around the sand dunes is one thing. Ongoing expansion of these activities needs to be prevented in areas where wild dunes still exist, and opportunities to increase set-backs where homes are re-built need to be taken advantage of. Areas such as the Pāpāmoa East/Te Tumu future developments need to be carefully considered and planned to avoid engulfing the dune lands in infrastructure, amenity lawns and exotic or inappropriate plantings. These are the kinds of things that could be better managed through plans and policies and a tight structure plan that considers biodiversity, and the services it provides, of equal importance to human habitation.

Mitigation and off-set mitigation are terms that seem to be used quite loosely around consenting processes, particularly where they abut or impact on biodiversity sites. An off-set should have the result of achieving no net loss in biodiversity (M Christensen, 2010), but most people interpret off-set mitigation as the ability to destroy one area of indigenous vegetation as long as some improvements are made to what remains. In addition, the concept of replacing like with like is often missed, and this is a critical factor when it applies to an ecosystem like dune lands that can not exist outside the coastal environment. It is not adequate to replace a lost dune with a new wetland. The result is still a net loss of dune land. Development projects should still seek to first avoid, then minimise impacts, before mitigation through off-set or other means is considered (M Christensen, 2010). There should also be a point where any further loss of a particular ecosystem type is considered inappropriate under any circumstances (M Christensen, 2010) and I would suggest that we have probably reached that point for dune lands.

9.4 Legal protection for dune land ecosystems

The first and most critical point about legal protection of dune land ecosystems is that legal protection is not the same as physical protection or management. It is simply a legal designation over a parcel of land. This appears to be forgotten in analyses at all levels where an assumption is made that a biodiversity site is 'safe' because it has a reserve designation over it. This is not the case. There are numerous examples of biodiversity sites that are declining in condition because they are not managed in any way and/or have no physical protection from impacts of damaging forces. The dune lands are a case in point.

Regardless of their legal designation, all dunes appear to be subject to the same forces of mostly negative change – human activity, exotic plants and animals. Legal protection is one tool, but it is inadequate on its own.

9.5 Vegetation change and current vegetation cover on dunes

It is no surprise that the vegetation changes on the dune landforms has been substantial in the Bay of Plenty. This situation is no different from the impacts on all ecosystem types, especially on the flatter lowlands. The dune vegetation that has been lost is now irretrievable, and maintenance and enhancement of the existing extent is the only option.

The Ministry for the Environment (2009) emphasises the need to secure and promote natural coastal margins as an environmental, social and cultural resource, as well as a form of coastal defence. They also encourage a pre-cautionary approach, although stated in terms of coastal hazard management. I consider that this should also apply to the biodiversity and natural character of dune land ecosystems so that they are maintained as a feature of the Bay of Plenty coastline indefinitely.

We still have wild and undeveloped dune areas that can be restored to something that more closely resembles their original state. Pest plant management will be the key to ensuring that indigenous species are maintained as the driving factors in the ecosystem. From a coastal hazard and erosion prevention perspective, indigenous plants are better suited to the development of lower dune angles that reduce the incidence of collapse (resulting in vertical scarps at the fore dune face) and blowouts, and have better capacity to repair steep scarps after periods of dune erosion. Indigenous species should be promoted and exotic species and pest plants progressively removed from the dunes.

Our specialised dune species will become extinct if the dunes landform is not maintained. Sand dunes can not be formed away from the coastal environment and they should not be encroached on, built upon or otherwise interfered with in such a way that natural erosion and repair processes are hampered in any way.

Exotic species do dominate the dunes in some areas, although largely the dunes still have a high component of indigenous species. High cover of pest plants is reasonably limited to some areas of the dunes, but some of those pest plants, such as pampas, boxthorn and agapanthus, can have a large impact on the dune ecosystem. It may not be feasible, logical, practical or systematic to control most pest plants in a species led approach.

Site led and species led approaches are best applied together[26]. The species led approach would tackle the worst low-incidence invaders that can be effectively reduced to zero density. This is complemented by a site led approach at identified High Value Ecological Sites as the first priority. Other sites could be targeted where there is an enthusiastic, committed care group, or in an area with a natural boundary where widespread pest plants can be effectively contained.

A mixture of species led and site led approaches would likely be required for TAs in particular, to meet the wants of the community at some sites. This would enable priority pest plants to be tackled over a larger area rather than expending resources on low priorities, while smaller areas of the dunes could be intensively managed and the area slowly expanded as pest plant management goes into the maintenance phase at each site. The biggest concern with pest plants is that often political and community pressure is applied to remove the most visible species, while the small and inconspicuous species, like exotic grasses, tend to be ignored. Once the highly visible species have been removed the pressure is placed elsewhere and the investment can be lost.

Pest plants require ongoing and long-term commitment of resources in order to achieve a high level of restoration of dunes to a high level of indigenous dominance. It is more likely that long term control and benefit will be gained where management focuses on parts of the dunes, removing pest plants and restoring indigenous cover to a high level before moving on to a new section. Long term monitoring and follow-up will be needed for all species as pest plants constantly re-invade and spread, and vigilance is required to keep them out.

The development of large long term pest plant management plans is unnecessary. There should be a planned approach, but any plan should be reviewable annually. Guidance on priority species would help operational staff to develop their annual work plans, and previous investment of resources should not be moved away from unless there is good reason. Any pest plant control programme should be accompanied by either a replanting programme or allowing natural succession if possible.

9.6 Impacts on dune lands

Again, it was not unexpected to find multiple and widespread negative impacts occurring on dunes throughout the region. The offset of positive impacts is not large enough to reduce these negative impacts significantly. It is disappointing to see the general public, including visitors to the region, treat the dunes with such a lack respect and care. A lot of the damage occurs because people are unwilling to go to the effort of, for example, walking from their vehicle to go fishing, or further along the beach to use a formed access way.

There are many tools being applied to the problems of rubbish dumping, grazing, vehicles and other impacts on the dunes. There has been no magic bullet and the only way that impacts will really be reduced is through changing the attitudes of the public to these coastal areas. Bylaws are clearly not working everywhere, although Western Bay of Plenty and Tauranga City Councils are having some success.

[26] Management options largely from John Mather (2010, pers comm.) with input from Walter Stahel

9.7 Operational work programmes on dunes

Expansion of Coast Care activities to cover all of the dune area, not just the frontal toe of the dunes, would provide greater benefits in maintaining stable and healthy dune systems. Coast Care is an existing partnership that works well and could achieve more given the resources. It is an accepted vehicle for restoration, education and attitude change amongst many communities. It is less threatening or binding than the Biodiversity Programme, and the key agencies are already involved and invested.

Site restoration with buy-in from locals and iwi would be the most effective, as they would have a greater feeling of control and ownership of the issues, which are largely driven by human activities.

The Biodiversity Programme also provides additional funding opportunities, with high grant rates for the most valuable parts of the dune system providing an incentive for private landowners and care groups to engage. But some landowners will always be reluctant to engage in this way because a Biodiversity Management Plan is a legal agreement and requires legal protection of the land.

Despite the fact that programmes do exist that can, and do, facilitate dune restoration to varying degrees, we still have no weed control occurring over most of the dunes. In some areas there is some weed control and at very few sites comprehensive weed control programmes have been undertaken. Given that dunelands are considered a national priority for protection, additional emphasis on their maintenance and enhancement is considered necessary in order to maintain them indefinitely.

9.8 General summary and conclusions

The ongoing damage and degradation currently visible on the dune lands through neglect and human activity indicates that dune lands are not adequately protected from damage and degradation. Vehicle use continues unabated, exotic species continue to invade, garden waste continues to be dumped. Rules and regulations under the Reserves Act, the Conservation Act, District and Regional plans and policies and council by-laws are not being acted on or enforced consistently across the region.

All administering bodies and private landowners responsible for the management of dunes are limited by funding and generally lack capacity for enforcement. A more coordinated and thorough approach that has clear priorities, targets and timelines has the potential to achieve far more than piece meal operations. A regional biodiversity strategy that covers the unique requirements of the dune land ecosystem may be one vehicle to achieve this level of coordination. Alternatively, active operational collaboration and coordination has potential to achieve better results for dunes. Maintenance and enhancement activities need to take into account the surrounding environment and sources of re-infestation of pest plants, animals and people and a biodiversity strategy could establish linkages to the four well beings (social, cultural, economic and environmental) to achieve this.

There are some aspects of the current monitoring methodology that can be improved. It should still, however, identify changes to the dune systems. We have seen a rapid decline in the extent of dune land vegetation in the past, and further losses should be prevented. It is likely that dune lands will continue to decline in condition if they are not managed for their biodiversity values and indigenous species maintained.

"The alternative [to a natural dune system] would be a considerable increase in the scale of hard coastal protection works that are installed. This may be an appropriate long-term strategy in certain (exceptional) circumstances, but does not fit comfortably with the values and principles of sustainably managing coastal margins" (Ministry for the Environment, 2009). Armouring and engineering hard protection "destroy the natural character of sand dunes including associated native flora and fauna, they also seriously impact on amenity use and aesthetics of beaches and interrupt the natural processes of dune erosion and repair" (Hesp, 2000).

We instinctively know that the dune lands are continuing to be degraded by all of the impacts listed and noted here. As with most ecosystem types in New Zealand, they are generally in at least a slow decline if the impacts upon them are not being managed. We need to increase management activities for biodiversity and ecological benefits and widen the current focus on erosion control to incorporate other goals over a larger proportion of the dune cross-section.

Part 10: Recommendations

- Add a quantitative component to the methodology (e.g. Scott Height Frequency points on transects).
- Investigate options for fauna survey and monitoring.
- Re-map the overall extent of the dunes in 2014 as a desktop exercise (with limited field validation, using up-to-date aerial photography and LIDAR.
- Re-measure transects in 2014.
- Re-map dune land vegetation in the field in 2019 year's time over the most up-to-date aerial photography.
- Field work should be completed at around the same time each year to reduce seasonal variation, and should be timed to coincide with flowering of grasses to aid identification in summer.
- Improve mapping of areas of actual works undertaken by Coast Care (rather than general activity areas), as this would improve outcome monitoring and enable the vegetation mapping to relate to areas under management and the benefits of that management.
- Expand Coast Care works into the rear dunes to provide wider coverage of the dune ecosystem.
- Continue to utilise Coast Care as a vehicle for education and changing attitudes to dunes.
- Develop some regional guidance on priority pest plants for control in dunes.
- Engage in BMPs with landowners of dune areas as opportunities arise.

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Appendices

Appendix 1 – Field survey methodology

This section summarises the field component of this project, adapted from Wildland Consultants (2008a). Full details are available in that report.

Desktop preparation

A spatial layer of the historic dunes landform was created, based on Geological Survey Maps of New Zealand and Hilton *et al* (2000), and current knowledge of consultant staff. Land use/land cover categories were defined and mapped onto the sand dune landforms over the 2007 aerial photography, or 2003 where the later photography was not available. The land cover categories were:

- Agriculture/Horticulture (includes pasture, orchards, cropping land etc);
- Plantation forest;
- Residential and built-up area (includes commercial, industrial etc);
- Roads/Parking areas/Railway line;
- Urban parkland (includes parks, green belts etc);
- Wild undeveloped areas.

They were mapped at 1:1000 for 2007 aerial photography, or 1:5000 for 2003 aerial photography.

The coastline was divided into sites based on site boundaries from Wildland Consultants (2006), with the areas that lay between those sites designated as another discrete site. They were assigned a Sand Dune Vegetation Mapping and Condition assessment site number and name (e.g. SDVC-18 Pukehina Spit). An electronic copy of the maps is included on the CD in the back cover of the report.

The vegetation cover of all areas of sand dunes identified as 'wild undeveloped areas' within the dune landform was mapped in detail.

Belt transects were located at one kilometre intervals along the entire coast, using a randomly generated starting point. Transects are 100 m wide, running perpendicular to the topographic coast line (from the NZMS260 map series). They terminate at the inland end of the wild undeveloped dune system, at managed margins or a change in landform (except at Matakana Island). Every site has at least one transect and for large sites, every vegetation type more than one hectare in size also has a transect. Where the one kilometre spacing did not achieve this, a process was defined for the placement of additional transects to meet this requirement. Transects were numbered consecutively with additional transects identified by a subsidiary number (e.g. 96.1). This enabled the process to be undertaken in the field, as it would not always be identified during the desk-top exercise, while still retaining the consecutive west to east numbering. Any transect dissecting non-dune areas were rejected but the numbering was not altered, so that transects established do not necessarily run in consecutive numbers.

Field survey

Aerial photographs were printed at 1:1000 scale showing boundaries of SDVC sites and transect locations. Vegetation mapping was undertaken during a walk through survey of each site and drawn on to hard copy maps for digitisation. Vegetation was described at three different levels – structural class, vegetation class, and vegetation types. Detailed vegetation types were recorded on field data sheets. Hydroclass and landforms for each vegetation type identified were also recorded.

Vegetation unit condition sheets were completed for each vegetation unit identifiable in the transects. The following was recorded:

- Field surveyor(s);
- Date of field survey;
- Transect number;
- Polygon number. The polygon number was used during the field survey to relate vegetation units to polygons mapped on aerials. Vegetation unit numbers were started from 1 for each transect;
- Vegetation type name (as per Atkinson 1985). Within height classes, the order of species within the vegetation type name follows their relative abundance from highest to lowest;
- Weeds: Presence and cover-abundance of weed species was recorded, as was the total cover of exotic species within the vegetation type;
- Threatened and significant plant species were assigned cover classes within each vegetation unit;
- Impacts: For each of the impacts which are observed within the vegetation type unit the intensity of the impact was scored as having a positive or negative effect on a scale of -3 to +3; and
- Additional notes.

Photographs were taken at each transect, two at the inland end of the transect offset at 45 degrees to the transect line. One photo was taken from the seaward end looking inland along the transect line.

Vegetation mapping was captured as polygons in a GIS shapefile, and this shapefile was used to calculate areas of each vegetation type present.

Appendix 2 – Methodology used in reporting

Analysis of different vegetation cover datasets over the historic dunes landform

Comparisons of other datasets against the historic landform were undertaken using Arc GIS software and using the Intersect function. This function overlays the datasets, removes any information and parts of polygons that fall outside the overlapping areas of both datasets, and then joins the attribute information of both datasets into one table (see Figure 30 below). The attribute table is then exported to an Excel workbook where the Pivot Table function is used to summarise and determine the total area in each vegetation cover category from the overlaid dataset (e.g. 1840 vegetation and Land Cover Database 2).

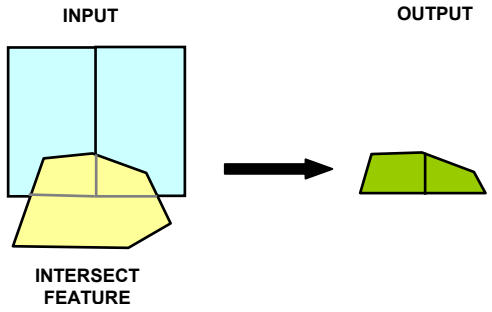


Figure 32 Illustration of ArcGIS intersect function.

Because the intersect function discards the non-overlapping areas, the total areas from each analysis do not match each other, or the total dunelands landform mapped by Wildland Consultants (2008a), with the greatest difference being 144 ha between the pre-human 1840 vegetation and the historic dunes landform mapping. These discrepancies are not considered major in terms of the broad picture of change to the dunes, given that all of the datasets used are approximations with varying error associated and in any case should be considered estimates only.

Nested data sets

The field data that was collected forms the basis of three tiers of nested datasets: Site data, vegetation mapping, transect data.

Most of the analysis for this work used the transect data because this is the finest scale of mapping and should provide the most information. Transect data can be complimented by site based data particularly in looking at threatened species with widely scattered distributions and low numbers. Some of these were missed in the transect data but identified in the site data, providing a fuller picture. For example, for *Austrofestuca littoralis* does not show on transects at the Kaituna Sand Dunes site, despite that area containing the largest population in the region. It does, however, register in the site information as occurring at that site. So in looking at spatial distribution, need to look at both the transects and the site data.

Transect data was collected for each vegetation polygon but not always translated to the overall transect. This meant that often the average of the polygons was used to represent the transect data and this is generally stated.

Vegetation type descriptions characterise the vegetation based on cover at different tiers for the most abundant species. This is not as useful as presence absence data at site or transect level for identifying serious pest plants and threatened or significant species, as the species is only apparent where it is part of the vegetation type name. This gives little

indication of its cover beyond the assumption, based on the Atkinson (1985) method, species are named in the description in decreasing order of abundance, so the first species named is the most abundant and will mostly attain at least 20% cover in that vegetation type.

Determining average cover on each transect

Cover of pest plants, threatened plants and indigenous cover (on some transects) was estimated using uneven cover classes, based on the recce plot method (Hurst and Allen, 2007). In analysis of vegetation cover the value used from each vegetation polygon to calculate the average cover for the transect is the midpoint of the cover class as follows in Table 8:

Table 8 Summary of cover classes and midpoints.

Cover class	Description	Midpoint (%)
1	<1%	0.5
2	1-5%	3.0
3	6-25%	15.0
4	26-50%	37.5
5	51-75%	62.5
6	76-100%	67.5
p	presence	0.5

Appendix 3 – Statement of National Priorities for protecting rare and threatened indigenous biodiversity on private land

National Priority 1:

To protect indigenous vegetation associated with land environments (defined by Land Environments of New Zealand at Level IV), that have 20% or less remaining in indigenous cover.

National Priority 2:

To protect indigenous vegetation associated with sand dunes and wetlands; ecosystem types that have become uncommon due to human activity.

National Priority 3:

To protect indigenous vegetation associated with 'originally rare' terrestrial ecosystem types not already covered by priorities 1 and 2.

National Priority 4:

To protect habitats of acutely and chronically threatened indigenous species.

Appendix 4 – Pest plants found in Bay of Plenty dunes and their RPMS status

Species – common name	Species – Latin name	Category in RPMS 2003-2008	Category in proposed RPMS
Agapanthus	*Agapanthus praecox*	Not included	Restricted pest
Arum lily	*Zantedeschia aethiopica*	Not included	Restricted pest
Banksia	*Banksia integrifolia*	Not included	Restricted pest
Blackberry	*Rubus sp. (R. fruticosus agg.)*	Boundary control	Containment pest (defined areas)
Blue morning glory	*Ipomoea indica*	Regional surveillance	Restricted pest
Boneseed	*Chrysanthemoides monolifera*	Progressive control	Containment pest
Bushy asparagus	*Asparagus densiflorus 'Sprengeri'*	Progressive control	Restricted pest
Climbing asparagus	*Asparagus scandens*	Regional surveillance	Restricted pest
Climbing dock	*Rumex saggitattus*	Not included	Restricted pest
Coastal tea tree	*Leptospermum laevigatum*	Not included	Containment pest
Crack willow	*Salix fragilis*	Not included	Restricted pest
Gorse	*Ulex europaeus*	Boundary control	Containment pest (defined areas)
Grey willow	*Salix cinerea*	Not included	Restricted pest
Italian buckthorn	*Rhamnus alaternus*	Regional surveillance	Containment pest
Japanese honeysuckle	*Lonicera japonica*	Not included	Restricted pest
Japanese spindle tree	*Euonymus japonicus*	Not included	Restricted pest
Lantana	*Lantana camara*	Progressive control	Containment pest
Mignonette vine	*Anredera cordifolia*	Regional surveillance	Restricted pest
Moth plant	*Araujia sericifera*	Regional surveillance	Restricted pest
Pampas	*Cortaderia selloana, Cortaderia jubata*	Regional surveillance	Restricted pest
Periwinkle	*Vinca major*	Not included	Restricted pest
Prickly pear cactus	*Opuntia vulgaris*	Not included	Restricted pest
Privet	Tree – *Ligustrum lucidum;* Chinese – *L. sinense*	Regional surveillance	Restricted pest

Radiata, patula and maritime pines	*Pinus radiata, P. patula and P. pinaster*	Not included	Included under 'wilding pines' outside planted areas – Restricted pest
Ragwort	*Senecio jacobaea*	Boundary control	Containment pest (defined areas)
Royal fern	*Osmunda regalis*	Eradication	Containment pest
Saltwater paspalum	*Paspalum vaginatum*	Not included	Restricted pest
Smilax	*Asparagus asparagoides*	Not included	Restricted pest
Taiwan cherry	*Prunus campanulata*	Not included	Restricted pest
Tuber ladder fern	*Nephrolepis cordifolia*	Not included	Restricted pest
Wild ginger	*Hedychium gardnerianum*	Progressive control	Containment pest
Woolly nightshade	*Solanum mauritianum*	Progressive control	Containment pest (defined areas)

Appendix 5: Reserves designations over mapped dune vegetation

Reserve types administered by Department of Conservation on mapped dune vegetation

Reserve Designation	Area (ha)
Government Purpose Reserve - s.22 Reserves Act 1977	194.33
Stewardship Area - s.25 Conservation Act 1987	73.75
Scenic Reserve - s.19(1)(a) Reserves Act 1977	28.26
Recreation Reserve - s.17 Reserves Act 1977	23.91
Fixed Marginal Strip - s.24(3) Conservation Act 1987	7.63
Historic Reserve - s.18 Reserves Act 1977	6.70
Grand Total	334.57

Reserves types administered by District Councils on mapped dune vegetation

Reserve Designation	Area (ha)
Reserve(Recreation)	203.17
Natural and Cultural Heritage District	150.07
Recreation	101.06
Esplanade	13.04
unknown designation	10.21
Landing	9.36
Reserve(Aerodrome)	7.02
Passive Local	1.56
Reserve(LP Segregation)	1.27
Passive District	0.71
Reserve(LP Coastal Protection)	0.55
Reserve(LP Refuse Transfer Stn	0.20
Commercial District	0.13
Reserve(LP Esplanade)	0.09
Council(Recreation)	0.01
Grand Total	498.48

Appendix 6: LCDB2 (2001/2002) Vegetation types for historic dunes landform and their comparability to current mapping

Table 9 Land cover type and area over historic dunes landform LCDB2.

Land Cover type	Area (ha)	% of total
High Producing Exotic Grassland	3,035.42	26.05
Built-up Area	1,979.54	16.99
Pine Forest - Open Canopy	1,546.31	13.27
Pine Forest - Closed Canopy	980.18	8.41
Forest Harvested	964.16	8.27
Low Producing Grassland	897.23	7.70
Urban Parkland/ Open Space	516.66	4.43
Broadleaved Indigenous Hardwoods	331.39	2.84
Herbaceous Freshwater Vegetation	269.09	2.31
Mixed Exotic Shrubland	240.40	2.06
Coastal Sand and Gravel	190.92	1.64
Indigenous Forest	135.90	1.17
Gorse and Broom	109.37	0.94
Manuka and or Kanuka	88.66	0.76
Other Exotic Forest	72.82	0.62
Lake and Pond	65.86	0.57
Short-rotation Cropland	60.25	0.52
Herbaceous Saline Vegetation	56.59	0.49
Afforestation (imaged, post LCDB 1)	31.92	0.27
River	26.99	0.23
Estuarine Open Water	21.55	0.18
Orchard and Other Perennial Crops	20.26	0.17
Major Shelterbelts	5.03	0.04
River and Lakeshore Gravel and Rock	4.89	0.04
Surface Mine	0.69	0.01
Deciduous Hardwoods	0.22	0.00
Mangrove	0.03	0.00
Grand Total	**1,1652.35**	**100.00**

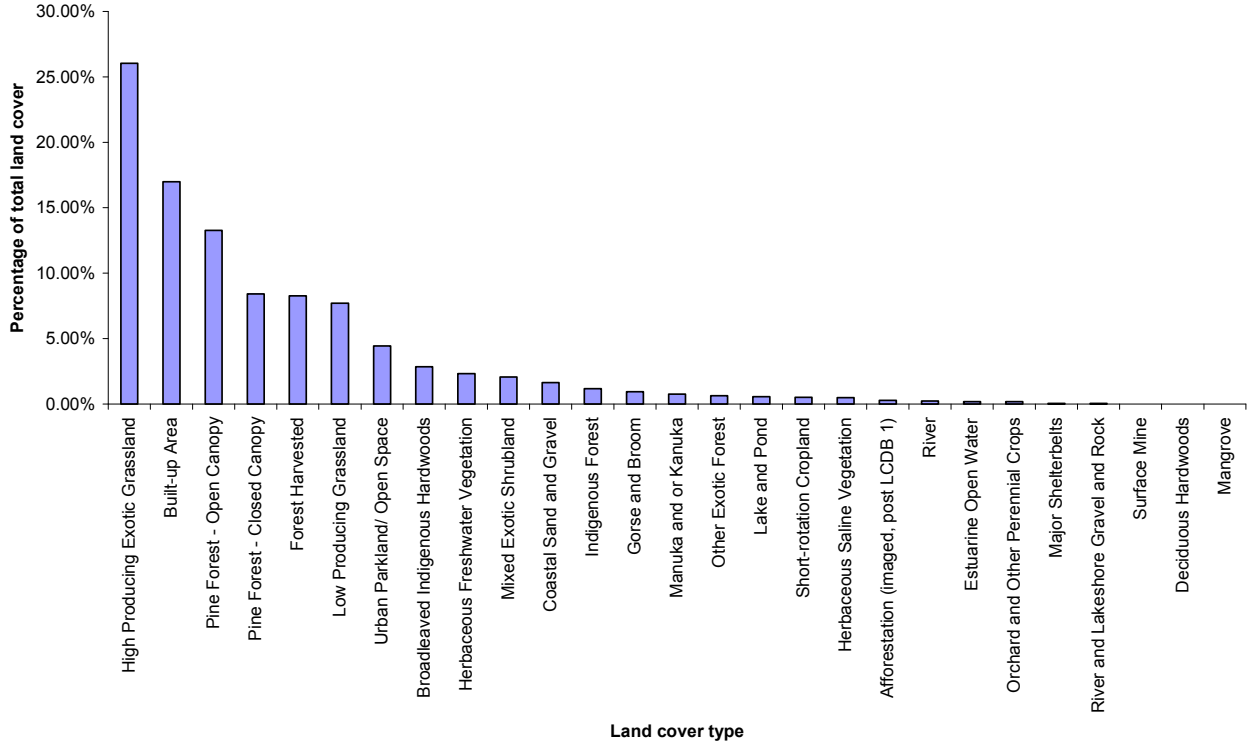


Figure 33 LCDB2 (2001/2002) Vegetation types for historic dunelands landform.

Discussion

LCDB2 was developed for use at a national scale and does not offer enough precision to provide more than a broad indication at regional level. The LCDB2 takes only the broadest structural dominants to a minimum mapping unit of one hectare using imagery with a 15 m spatial resolution (NZ Climate Change Office, 2004). The duneland mapping is designed for the scale of regional duneland vegetation, aiming to identify all the broad vegetation types present at a 1:1000 to 1:5000 scale.

The dunelands mapping does provide some ground truthing results for the LCDB2, identifying areas wrongly attributed to each category. For example, “broadleaved indigenous hardwoods” is variously mapped in one part of the dunelands vegetation as pine treeland, sea couch dominant grassland, Banksia treeland (an exotic dominant vegetation type), vineland and sedgeland. None of these categories could be considered broadleaved indigenous hardwoods, but the LCDB doesn’t define cover types to that scale,

What the LCDB2 does tell us, is that at a broad scale 81.13% of the historic dune land form has been developed into the categories shown in Table 9. Only 17.84% could be considered to be ‘wild and undeveloped’. Note that ‘low producing grassland’ and ‘gorse and broom’ categories are included in the 17.84% as these landcover types occur mostly in the ‘wild and undeveloped’ dune vegetation areas mapped in 2009. The remaining 1.02% in LCDB2 was ‘estuarine open water’, ‘river and lakeshore gravel and rock’, ‘river’, ‘lake and pond’.

As an exercise in ground truthing the LCDB2, the numbers correlate reasonably well to the numbers from the duneland mapping exercise. The mapped vegetation area (2118 ha), the ‘wild and undeveloped’ category of the duneland work, is only a little higher than that suggested by the LCDB2 classes that are not clearly part of the developed landscape (2079.15). So despite differences in scale and detail, the LCDB2 has been reasonably accurate in identifying what is developed on the dune landform and what is not. It is not, however, capable of defining vegetation types within the dunes landform to a level of detail that would be suitable for the NERMN programme.

The comparison also suggests that little or no additional area of dune vegetation has been lost to development between 2001/2002 and 2009.

There is an earlier Land Cover Database from 1996. A comparison of the data was made between the 1996 and the 2001/2002 versions, however the changes were so small that it was meaningless to present an analysis of the change between the two LCDBs over the exotic dune landform. Most of the change related to pine forestry rotations where variations in open and closed canopy pine forest and harvested areas balanced out to the same area of pine forest land use as a whole. There were also some changes from exotic grassland to built-up area, but they did not add anything meaningful to the analysis.

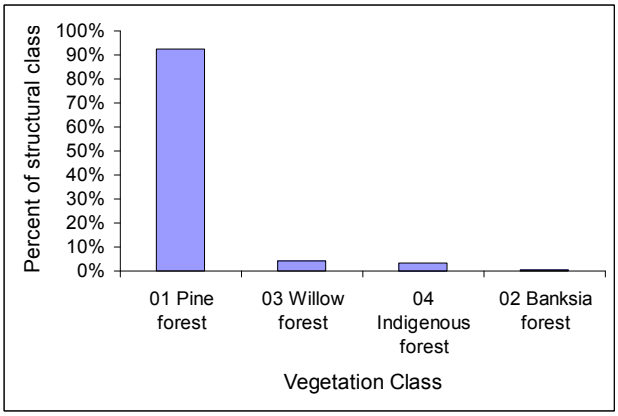
Appendix 7: Indigenous dominant vegetation types in the taller structural classes

Structural class and vegetation class	Area (ha)	% of total dune vegetation
01.04 Indigenous forest	8.28	0.39
02.06 Mixed indigenous treeland	0.58	0.25
02.07 Pohutukawa treeland	3.53	0.17
04.01 Mixed indigenous scrub	14.76	0.70
04.07 Manuka scrub	0.21	0.01
05.01 Manuka shrubland	1.48	0.07
05.02 Ti kouka-taupata shrubland	0.45	0.02
05.08 Coastal kanuka shrubland	9.62	0.45
05.09 Saltmarsh ribbonwood shrubland	1.53	0.07
05.10 Kanuka shrubland	0.59	0.03
05.11 Mixed indigenous shrubland	0.63	0.03
TOTAL	**50.72**	**2.19**

Appendix 8: Vegetation Class composition of each Structural Class

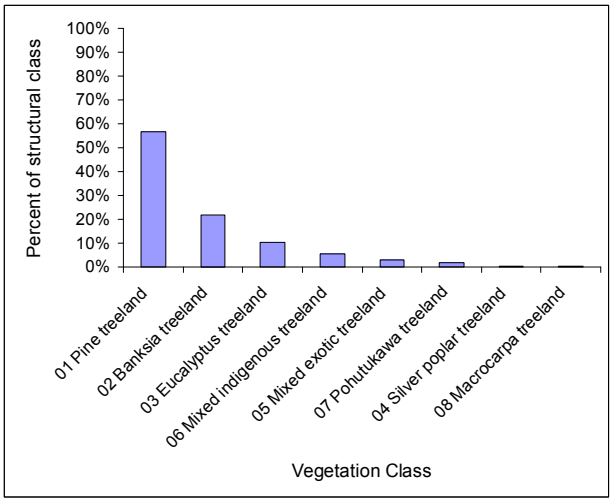
The graphs and tables below break down each structural class to its broad vegetation classes.

01 Forest



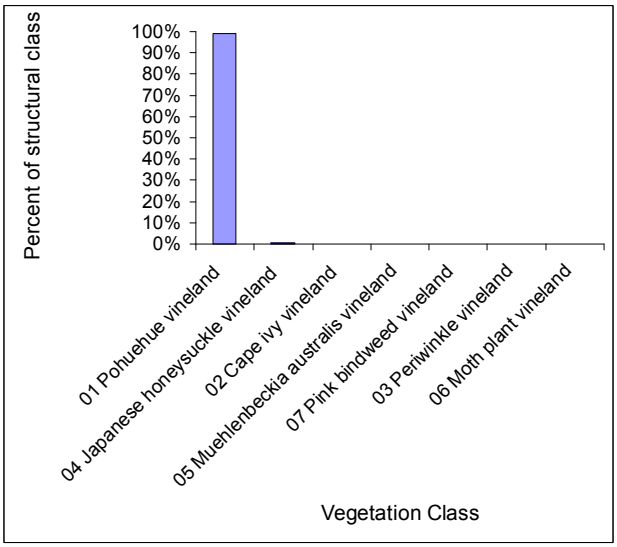
Vegetation Class	Area (ha)	% of structural class
01 Pine forest	229.34	92.32
03 Willow forest	10.00	4.03
04 Indigenous forest	8.28	3.33
02 Banksia forest	0.80	0.32
TOTAL Forest	248.42	100.00

02 Treeland



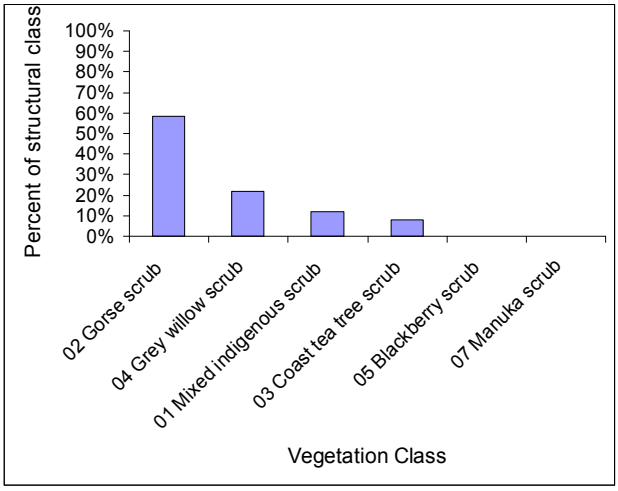
Vegetation Class	Area (ha)	% of structural class
01 Pine treeland	100.63	56.51%
02 Banksia treeland	39.11	21.96%
03 Eucalyptus treeland	18.76	10.54%
06 Mixed indigenous treeland	9.65	5.42%
05 Mixed exotic treeland	5.25	2.95%
07 Pohutukawa treeland	3.53	1.98%
04 Silver poplar treeland	0.58	0.32%
08 Macrocarpa treeland	0.55	0.31%
TOTAL Treeland	178.06	100.00%

03 Vineland



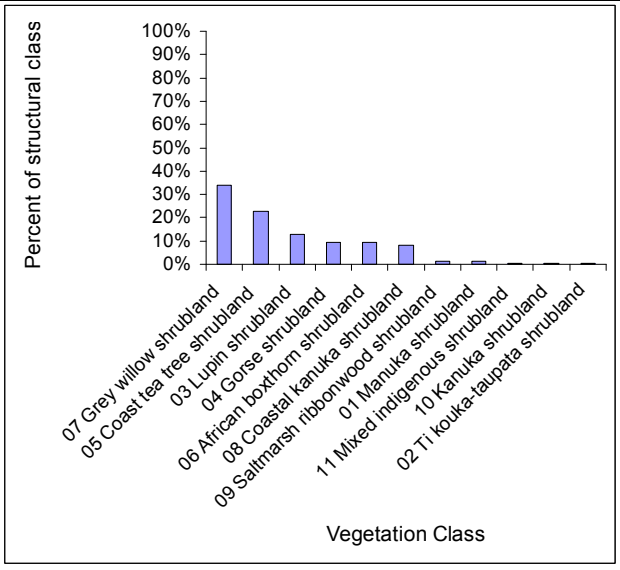
Vegetation Class	Area (ha)	% of structural class
01 Pohuehue vineland	373.97	99.14%
04 Japanese honeysuckle vineland	2.04	0.54%
02 Cape ivy vineland	0.58	0.15%
05 *Muehlenbeckia australis* vineland	0.34	0.09%
07 Pink bindweed vineland	0.21	0.06%
03 Periwinkle vineland	0.05	0.01%
06 Moth plant vineland	0.03	0.01%
TOTAL Vineland	377.21	100.00%

04 Scrub



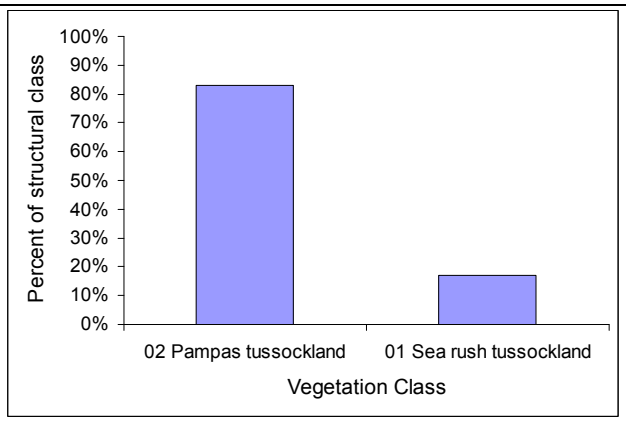
Vegetation Class	Area (ha)	% of structural class
02 Gorse scrub	72.22	58.22%
04 Grey willow scrub	26.74	21.56%
01 Mixed indigenous scrub	14.76	11.90%
03 Coast tea tree scrub	9.85	7.95%
05 Blackberry scrub	0.25	0.20%
07 Manuka scrub	0.21	0.17%
TOTAL Scrub	124.03	100.00%

05 Shrubland



Vegetation Class	Area (ha)	% of structural class
07 Grey willow shrubland	40.82	33.81%
05 Coast tea tree shrubland	27.49	22.76%
03 Lupin shrubland	15.39	12.74%
04 Gorse shrubland	11.40	9.44%
06 African boxthorn shrubland	11.38	9.42%
08 Coastal kanuka shrubland	9.62	7.96%
09 Saltmarsh ribbonwood shrubland	1.53	1.27%
01 Manuka shrubland	1.48	1.22%
11 Mixed indigenous shrubland	0.63	0.52%
10 Kanuka shrubland	0.59	0.49%
02 Ti kouka-taupata shrubland	0.45	0.37%
TOTAL Shrubland	120.76	100.00%

06 Tussockland

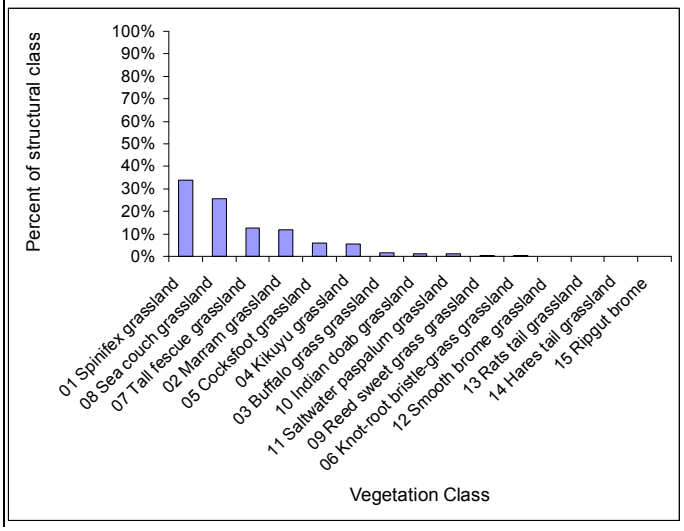


Vegetation Class	Area (ha)	% of structural class
02 Pampas tussockland	20.72	82.92%
01 Sea rush tussockland	4.27	17.08%
TOTAL Tussockland	24.98	100.00%

07 Fernland

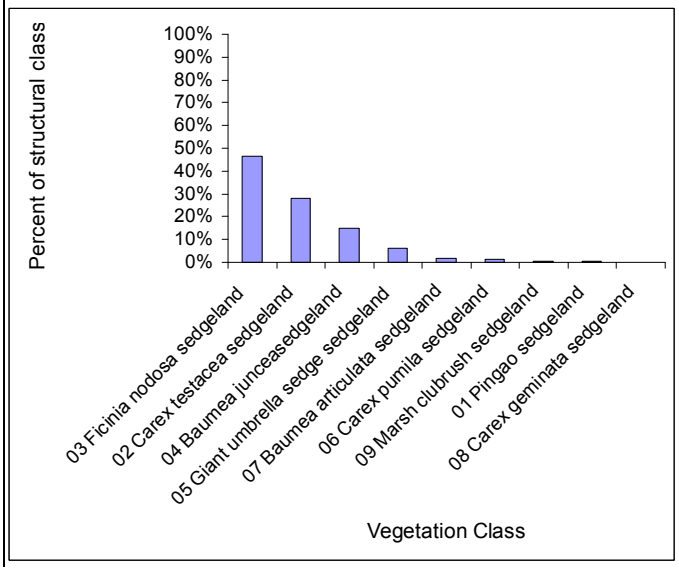
Structural class is entirely bracken fernland (66 ha).

08 Grassland



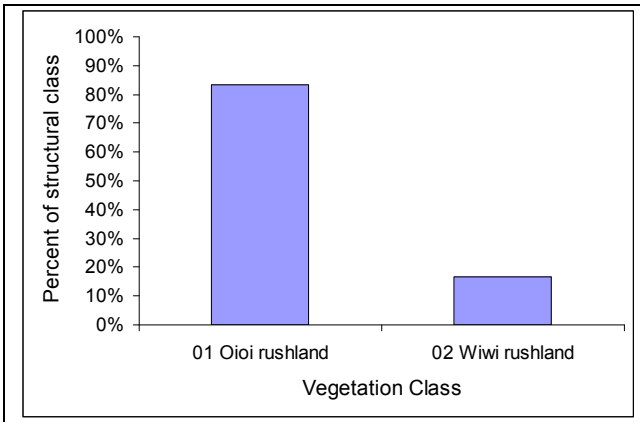
Vegetation Class	Area (ha)	% of structural class
01 Spinifex grassland	190.84	34.04%
08 Sea couch grassland	143.21	25.54%
07 Tall fescue grassland	70.56	12.58%
02 Marram grassland	65.37	11.66%
05 Cocksfoot grassland	32.72	5.84%
04 Kikuyu grassland	30.76	5.49%
03 Buffalo grass grassland	8.06	1.44%
10 Indian doab grassland	7.40	1.32%
11 Saltwater paspalum grassland	5.98	1.07%
09 Reed sweet grass grassland	3.01	0.54%
06 Knot-root bristle-grass grassland	2.02	0.36%
12 Smooth brome grassland	0.33	0.06%
13 Rats tail grassland	0.23	0.04%
14 Hares tail grassland	0.13	0.02%
15 Ripgut brome	0.08	0.01%
TOTAL Grassland	560.69	100.00%

09 Sedgeland



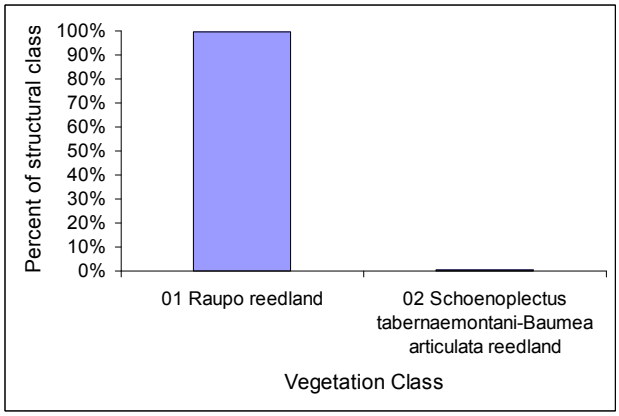
Vegetation Class	Area (ha)	% of structural class
03 *Ficinia nodosa* sedgeland	69.94	46.67%
02 *Carex testacea* sedgeland	42.19	28.15%
04 *Baumea juncea* sedgeland	22.02	14.70%
05 Giant umbrella sedge sedgeland	9.00	6.00%
07 *Baumea articulata* sedgeland	2.83	1.89%
06 *Carex pumila* sedgeland	2.08	1.39%
09 Marsh clubrush sedgeland	0.85	0.57%
01 Pingao sedgeland	0.69	0.46%
08 *Carex geminata* sedgeland	0.25	0.17%
TOTAL Sedgeland	149.85	100.00%

10 Rushland



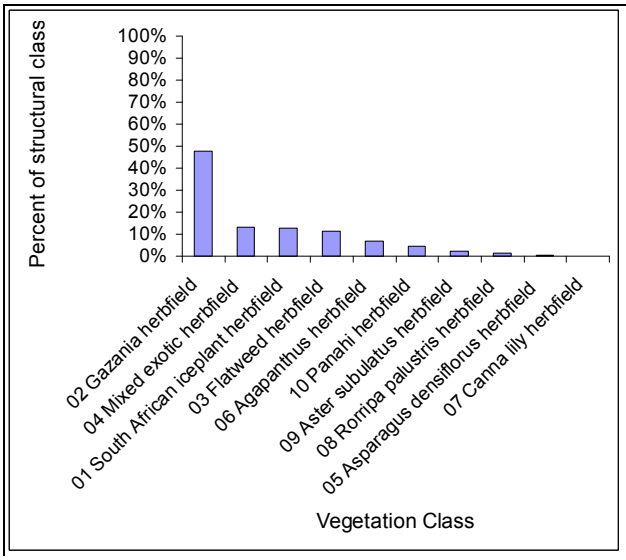
Vegetation Class	Area (ha)	% of structural class
01 Oioi rushland	14.31	83.31%
02 Wiwi rushland	2.87	16.69%
TOTAL Rushland	17.1764862	100.00%

11 Reedland



Vegetation Class	Area (ha)	% of structural class
01 Raupo reedland	127.20	99.67%
02 *Schoenoplectus tabernaemontani-Baumea articulata* reedland	0.42	0.33%
	127.62	100.00%

12 Herbfield



Vegetation Class	Area (ha)	% of structural class
02 Gazania herbfield	8.55	47.51%
04 Mixed exotic herbfield	2.36	13.11%
01 South African iceplant herbfield	2.30	12.76%
03 Flatweed herbfield	2.01	11.19%
06 Agapanthus herbfield	1.20	6.68%
10 Panahi herbfield	0.82	4.57%
09 *Aster subulatus* herbfield	0.42	2.33%
08 *Rorripa palustris* herbfield	0.24	1.32%
05 *Asparagus densiflorus* herbfield	0.09	0.48%
07 Canna lily herbfield	0.01	0.05%
	18.00	100.00%

19 Sandfield and 20 Open water

Neither structural class breaks down any further.

Appendix 9: Landform definitions

(from Hesp, 2000)

Berm: A wave-built terrace landform lying between dunes and high water. Unvegetated dry sand on the surface of berms constitutes a significant source of aeolian[27] sand.

Blowout: Blowouts are erosional dune landforms. They are either saucer-, cup-, bowl-, or trough-shaped depressions or hollows formed by wind erosion of a pre-existing sandy substrate or dune.

Established foredune: Established foredunes are older, more permanent foredunes. They develop from incipient foredunes and are distinguished by the growth of intermediate, often woody plant species, and commonly by their greater complexity of form, height, and width.

Foredune plain: A coastal plain comprising two or more foredunes.

Incipient foredune: A new foredune formed by Aeolian sand deposition within pioneer plants commonly on the back of the beach above the spring high tide line.

Transgressive dunefield: Transgressive dunefields are relatively large-scale Aeolian sand deposits formed by the downwind and/or alongshore movement (or transgression) of sand over vegetated to semi-vegetated terrain.

[27] wind-blown

Appendix 10: List of impacts scored

Litter
Pest plants
Vehicle tracks
Rabbits
Walking tracks (unofficial)
Pest plant control
Blowouts
Restoration plantings
Walking tracks (official)
Organic waste dumping
Aesthetic indigenous plantings
Recreation impact
Exotic gardens
Inorganic waste dumping
Drains
Snails
Other vegetation clearance
Erosion
Weeds
Grazing
Fence
Pigs
Slugs
Effluent pond breathers
Driftwood
Previously grazed
Sea wall